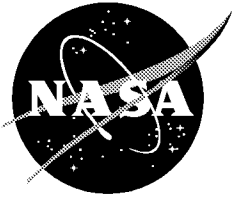


NASA/SP—2000–6110



Failure Modes and Effects Analysis (FMEA)

A Bibliography

National Aeronautics and Space Administration

July 2000

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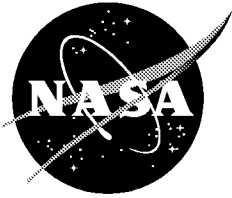
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Failure Mode and Effects Analysis (FMEA)

A Bibliography

National Aeronautics and
Space Administration

NASA Scientific and Technical
Information Program

July 2000

Introduction

Failure modes and effects analysis (FMEA) is a bottom–up analytical process which identifies process hazards. This bibliography contains references to documents in the NASA Scientific and Technical Information (STI) Database. The selections are based on the major concepts and other NASA Thesaurus terms, including 'failure analysis.' An abstract is included with most citations.

Items are first categorized by 10 major subject divisions, then further divided into 76 specific subject categories, based on the NASA Scope and Subject Category Guide. The subject divisions and categories are listed in the Table of Contents together with a note for each that defines its scope and provides any cross-references.

Two indexes, Subject Term and Personal Author are also included. The Subject Term Index is generated from the NASA Thesaurus terms associated and listed with each document.

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Subject Divisions

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| C. Chemistry and Materials | J. Space Sciences |
| D. Engineering | K. General |
| E. Geosciences | |
| F. Life Sciences | |
| G. Mathematical and Computer Sciences | |

Indexes

Two indexes are available. You may use the find command under the tools menu while viewing the PDF file for direct match searching on any text string. You may also select either of the two indexes provided for searching on *NASA Thesaurus* subject terms and personal author names.

[Subject Term Index](#)

[Personal Author Index](#)

Document Availability

Select [Availability Info](#) for important information about NASA Scientific and Technical Information (STI) Program Office products and services, including registration with the NASA Center for AeroSpace Information (CASI) for access to the NASA CASI TRS (Technical Report Server), and availability and pricing information for cited documents.

Subject Categories of the Division A. Aeronautics

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

- | | | |
|-----------|--|-------------|
| 01 | Aeronautics (General) | 1 |
| | <p>Includes general research topics related to manned and unmanned aircraft and the problems of flight within the Earth's atmosphere. Also includes manufacturing, maintenance, and repair of aircraft. For specific topics in aeronautics see <i>categories 02 through 09</i>. For information related to space vehicles see <i>12 Astronautics</i>.</p> | |
| 02 | Aerodynamics | N.A. |
| | <p>Includes aerodynamics of flight vehicles, test bodies, airframe components and combinations, wings, and control surfaces. Also includes aerodynamics of rotors, stators, fans and other elements of turbomachinery. For related information, see also <i>34 Fluid Mechanics and Heat Transfer</i>.</p> | |
| 03 | Air Transportation and Safety | 1 |
| | <p>Includes passenger and cargo air transport operations; aircraft ground operations; flight safety and hazards; and aircraft accidents. Systems and hardware specific to ground operations of aircraft and to airport construction are covered in <i>09 Research and Support Facilities (Air)</i>. Air traffic control is covered in <i>04 Aircraft Communications and Navigation</i>. For related information see also <i>16 Space Transportation and Safety</i>; and <i>85 Technology Utilization and Surface Transportation</i>.</p> | |
| 04 | Aircraft Communications and Navigation | 2 |
| | <p>Includes all modes of communication with and between aircraft; air navigation systems (satellite and ground based); and air traffic control. For related information see also <i>06 Avionics and Aircraft Instrumentation</i>; <i>17 Space Communications</i>; <i>Spacecraft Communications, Command and Tracking</i>, and <i>32 Communications and Radar</i>.</p> | |
| 05 | Aircraft Design, Testing and Performance | 4 |
| | <p>Includes all stages of design of aircraft and aircraft structures and systems. Also includes aircraft testing, performance, and evaluation, and aircraft and flight simulation technology. For related information, see also <i>18 Spacecraft Design, Testing and Performance</i> and <i>39 Structural Mechanics</i>. For land transportation vehicles, see <i>85 Technology Utilization and Surface Transportation</i>.</p> | |
| 06 | Avionics and Aircraft Instrumentation | 5 |
| | <p>Includes all avionics systems, cockpit and cabin display devices; and flight instruments intended for use in aircraft. For related information, see also <i>04 Aircraft Communications and Navigation</i>; <i>08 Aircraft Stability and Control</i>; <i>19 Spacecraft Instrumentation and Astrionics</i>; and <i>35 Instrumentation and Photography</i>.</p> | |

- | | | |
|-----------|--|-------------|
| 07 | Aircraft Propulsion and Power | 6 |
| | Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and onboard auxiliary power plants for aircraft. For related information see also <i>20 Spacecraft Propulsion and Power</i> , <i>28 Propellants and Fuels</i> , and <i>44 Energy Production and Conversion</i> . | |
| 08 | Aircraft Stability and Control | N.A. |
| | Includes flight dynamics, aircraft handling qualities; piloting; flight controls; and autopilots. For related information, see also <i>05 Aircraft Design, Testing and Performance</i> and <i>06 Avionics and Aircraft Instrumentation</i> . | |
| 09 | Research and Support Facilities (Air) | N.A. |
| | Includes airports, runways, hangars, and aircraft repair and overhaul facilities; wind tunnels, water tunnels, and shock tubes; flight simulators; and aircraft engine test stands. Also includes airport ground equipment and systems. For airport ground operations see <i>03 Air Transportation and Safety</i> . For astronautical facilities see <i>14 Ground Support Systems and Facilities (Space)</i> . | |

Subject Categories of the Division B. Astronautics

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

- | | | |
|-----------|---|-------------|
| 12 | Astronautics (General) | 9 |
| | Includes general research topics related to space flight and manned and unmanned space vehicles, platforms or objects launched into, or assembled in, outer space; and related components and equipment. Also includes manufacturing and maintenance of such vehicles or platforms. For specific topics in astronautics see <i>categories 13 through 20</i> . For extraterrestrial exploration, see <i>91 Lunar and Planetary Science and Exploration</i> . | |
| 13 | Astrodynamics | N.A. |
| | Includes powered and free-flight trajectories; and orbital and launching dynamics. | |
| 14 | Ground Support Systems and Facilities (Space) | 10 |
| | Includes launch complexes, research and production facilities; ground support equipment, e.g., mobile transporters; and test chambers and simulators. Also includes extraterrestrial bases and supporting equipment. For related information see also <i>09 Research and Support Facilities (Air)</i> . | |
| 15 | Launch Vehicles and Launch Operations | N.A. |
| | Includes all classes of launch vehicles, launch/space vehicle systems, and boosters; and launch operations. For related information see also <i>18 Spacecraft Design, Testing, and Performance</i> ; and <i>20 Spacecraft Propulsion and Power</i> . | |

- | | | |
|----|--|------|
| 16 | Space Transportation and Safety | 10 |
| | Includes passenger and cargo space transportation, e.g., shuttle operations; and space rescue techniques. For related information, see also <i>03 Air Transportation and Safety</i> and <i>15 Launch Vehicles and Launch Vehicles</i> , and <i>18 Spacecraft Design, Testing and Performance</i> . For space suits, see <i>54 Man/System Technology and Life Support</i> . | |
| 17 | Space Communications, Spacecraft Communications, Command and Tracking | N.A. |
| | Includes space systems telemetry; space communications networks; astronavigation and guidance; and spacecraft radio blackout. For related information, see also <i>04 Aircraft Communications and Navigation</i> and <i>32 Communications and Radar</i> . | |
| 18 | Spacecraft Design, Testing and Performance | 45 |
| | Includes satellites; space platforms; space stations; spacecraft systems and components such as thermal and environmental controls; and spacecraft control and stability characteristics. For life support systems, see <i>54 Man/System Technology and Life Support</i> . For related information, see also <i>05 Aircraft Design, Testing and Performance</i> , <i>39 Structural Mechanics</i> , and <i>16 Space Transportation and Safety</i> . | |
| 19 | Spacecraft Instrumentation and Astrionics | N.A. |
| | Includes the design, manufacture, or use of devices for the purpose of measuring, detecting, controlling, computing, recording, or processing data related to the operation of space vehicles or platforms. For related information, see also <i>06 Aircraft Instrumentation and Avionics</i> ; For spaceborne instruments not integral to the vehicle itself see <i>35 Instrumentation and Photography</i> ; For spaceborne telescopes and other astronomical instruments see <i>89 Astronomy, Instrumentation and Photography</i> ; For spaceborne telescopes and other astronomical instruments see <i>89 Astronomy</i> . | |
| 20 | Spacecraft Propulsion and Power | 46 |
| | Includes main propulsion systems and components, e.g., rocket engines; and spacecraft auxiliary power sources. For related information, see also <i>07 Aircraft Propulsion and Power</i> ; <i>28 Propellants and Fuels</i> ; <i>15 Launch Vehicles and Launch Operations</i> ; and <i>44 Energy Production and Conversion</i> . | |

Subject Categories of the Division C. Chemistry and Materials

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

- | | | |
|----|--|------|
| 23 | Chemistry and Materials (General) | N.A. |
| | Includes general research topics related to the composition, properties, structure, and use of chemical compounds and materials as they relate to aircraft, launch vehicles, and spacecraft. For specific topics in chemistry and materials see <i>categories 24 through 29</i> . For astrochemistry see category <i>90 Astrophysics</i> . | |

- | | | |
|----|---|------|
| 24 | Composite Materials | 53 |
| | Includes physical, chemical, and mechanical properties of laminates and other composite materials. | |
| 25 | Inorganic, Organic, and Physical Chemistry | N.A. |
| | Includes the analysis, synthesis, and use inorganic and organic compounds; combustion theory; electrochemistry; and photochemistry. For related information see also <i>34 Fluid Dynamics and Thermodynamics</i> , <i>For astrochemistry see category 90 Astrophysics</i> . | |
| 26 | Metals and Metallic Materials | 68 |
| | Includes physical, chemical, and mechanical properties of metals and metallic materials; and metallurgy. | |
| 27 | Nonmetallic Materials | 70 |
| | Includes physical, chemical, and mechanical properties of plastics, elastomers, lubricants, polymers, textiles, adhesives, and ceramic materials. For composite materials see <i>24 Composite Materials</i> . | |
| 28 | Propellants and Fuels | 72 |
| | Includes rocket propellants, igniters and oxidizers; their storage and handling procedures; and aircraft fuels. For nuclear fuels see <i>73 Nuclear Physics</i> . For related information see also <i>07 Aircraft Propulsion and Power</i> , <i>20 Spacecraft Propulsion and Power</i> , and <i>44 Energy Production and Conversion</i> . | |
| 29 | Space Processing | N.A. |
| | Includes space-based development of materials, compounds, and processes for research or commercial application. Also includes the development of materials and compounds in simulated reduced-gravity environments. For legal aspects of space commercialization see <i>84 Law, Political Science and Space Policy</i> . | |

Subject Categories of the Division D. Engineering

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

- | | | |
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| 31 | Engineering (General) | 74 |
| | Includes general research topics to engineering and applied physics, and particular areas of vacuum technology, industrial engineering, cryogenics, and fire prevention. For specific topics in engineering see <i>categories 32 through 39</i> . | |

- 32 Communications and Radar N.A.**
- Includes radar; radio, wire, and optical communications; land and global communications; communications theory. For related information see also *04 Aircraft Communications and Navigation*; and *17 Space Communications, Spacecraft Communications, Command and Tracking*; for search and rescue see *03 Air Transportation and Safety*, and *16 Space Transportation and Safety*.
- 33 Electronics and Electrical Engineering 74**
- Includes development, performance, and maintainability of electrical/electronic devices and components; related test equipment. and microelectronics and integrated circuitry. For related information see also *60 Computer Operations and Hardware*; and *76 Solid-State Physics*. For communications equipment and devices see *32 Communications and Radar*.
- 34 Fluid Mechanics and Thermodynamics N.A.**
- Includes fluid dynamics and kinematics and all forms of heat transfer; boundary layer flow; hydrodynamics; hydraulics; fluidics; mass transfer and ablation cooling. For related information see also *02 Aerodynamics*.
- 35 Instrumentation and Photography 79**
- Includes remote sensors; measuring instruments and gauges; detectors; cameras and photographic supplies; and holography. For aerial photography see *43 Earth Resources and Remote Sensing*. For related information see also *06 Avionics and Aircraft Instrumentation*; and *19 Spacecraft Instrumentation*.
- 36 Lasers and Masers 80**
- Includes lasing theory, laser pumping techniques, maser amplifiers, laser materials, and the assessment of laser and maser outputs. For cases where the application of the laser or maser is emphasized see also the specific category where the application is treated. For related information see also *76 Solid-State Physics*.
- 37 Mechanical Engineering 81**
- Includes mechanical devices and equipment; machine elements and processes. For cases where the application of a device or the host vehicle is emphasized see also the specific category where the application or vehicle is treated. For robotics see *63 Cybernetics, Artificial Intelligence, and Robotics*; and *54 Man/System Technology and Life Support*.
- 38 Quality Assurance and Reliability 86**
- Includes approaches to, and methods for reliability analysis and control, inspection, maintainability, and standardization.

- 39 Structural Mechanics 111**
- Includes structural element design, analysis and testing; dynamic responses of structures; weight analysis; fatigue and other structural properties; and mechanical and thermal stresses in structure. For applications see *05 Aircraft Design, Testing and Performance* and *18 Spacecraft Design, Testing and Performance*.

Subject Categories of the Division E. Geosciences

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

- 42 Geosciences (General) N.A.**
- Includes general research topics related to the Earth sciences, and the specific areas of petrology, mineralogy, and general geology. For other specific topics in geosciences see *categories 42 through 48*.
- 43 Earth Resources and Remote Sensing N.A.**
- Includes remote sensing of earth features, phenomena and resources by aircraft, balloon, rocket, and spacecraft; analysis of remote sensing data and imagery; development of remote sensing products; photogrammetry; and aerial photographs. For instrumentation see *35 Instrumentation and Photography*.
- 44 Energy Production and Conversion 125**
- Includes specific energy conversion systems, e.g., fuel cells; and solar, geothermal, windpower, and waterwave conversion systems; energy storage; and traditional power generators. For technologies related to nuclear energy production see *73 Nuclear Physics*. For related information see also *07 Aircraft Propulsion and Power*; *20 Spacecraft Propulsion and Power*, and *28 Propellants and Fuels*.
- 45 Environment Pollution N.A.**
- Includes atmospheric, water, soil, noise, and thermal pollution.
- 46 Geophysics 128**
- Includes earth structure and dynamics, aeronomy; upper and lower atmosphere studies; ionospheric and magnetospheric physics; and geomagnetism. For related information see *47 Meteorology and Climatology*; and *93 Space Radiation*.
- 47 Meteorology and Climatology N.A.**
- Includes weather observation forecasting and modification.
- 48 Oceanography N.A.**
- Includes the physical, chemical and biological aspects of oceans and seas; ocean dynamics, and marine resources. For related information see also *43 Earth Resources and Remote Sensing*.

Subject Categories of the Division F. Life Sciences

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

51 Life Sciences (General) N.A.

Includes general research topics related to plant and animal biology (non-human); ecology; microbiology; and also the origin, development, structure, and maintenance, of animals and plants in space and related environmental conditions. For specific topics in life sciences see *categories 52 through 55*.

52 Aerospace Medicine N.A.

Includes the biological and physiological effects of atmospheric and space flight (weightlessness, space radiation, acceleration, and altitude stress) on the human being; and the prevention of adverse effects on those environments. For psychological and behavioral effects of aerospace environments see *53 Behavioral Science*. For the effects of space on animals and plants see *51 Life Sciences*.

53 Behavioral Sciences N.A.

Includes psychological factors; individual and group behavior; crew training and evaluation; and psychiatric research.

54 Man/System Technology and Life Support N.A.

Includes human factors engineering; bionics, man-machine, life support, space suits and protective clothing. For related information see also *16 Space Transportation* and *52 Aerospace Medicine*.

55 Exobiology N.A.

Includes astrobiology; planetary biology; and extraterrestrial life. For the biological effects of aerospace environments on humans see *52 Aerospace medicine*; on animals and plants see *51 Life Sciences*. For psychological and behavioral effects of aerospace environments see *53 Behavioral Science*.

Subject Categories of the Division G. Mathematical and Computer Sciences

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

59 Mathematical and Computer Sciences (General) N.A.

Includes general topics and overviews related to mathematics and computer science. For specific topics in these areas see *categories 60 through 67*.

60	Computer Operations and Hardware	129
	Includes hardware for computer graphics, firmware and data processing. For components see <i>33 Electronics and Electrical Engineering</i> . For computer vision see <i>63 Cybernetics, Artificial Intelligence and Robotics</i> .	
61	Computer Programming and Software	129
	Includes software engineering, computer programs, routines, algorithms, and specific applications, e.g., CAD/CAM. For computer software applied to specific applications, see also the associated category.	
62	Computer Systems	N.A.
	Includes computer networks and distributed processing systems. For information systems see <i>82 Documentation and Information Science</i> . For computer systems applied to specific applications, see the associated category.	
63	Cybernetics, Artificial Intelligence and Robotics	136
	Includes feedback and control theory, information theory, machine learning, and expert systems. For related information see also <i>54 Man/System Technology and Life Support</i> .	
64	Numerical Analysis	139
	Includes iteration, differential and difference equations, and numerical approximation.	
65	Statistics and Probability	140
	Includes data sampling and smoothing; Monte Carlo method; time series and analysis; and stochastic processes.	
66	Systems Analysis and Operations Research	140
	Includes mathematical modeling of systems; network analysis; mathematical programming; decision theory; and game theory.	
67	Theoretical Mathematics	N.A.
	Includes algebra, functional analysis, geometry, topology set theory, group theory and number theory.	

Subject Categories of the Division H. Physics

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

70	Physics (General)	N.A.
	Includes general research topics related to mechanics, kinetics, magnetism, and electrodynamics. For specific areas of physics see <i>categories 71 through 77</i> . For related instrumentation see <i>35 Instrumentation and Photography</i> ; for geophysics, astrophysics or solar physics see <i>46 Geophysics</i> , <i>90 Astrophysics</i> , or <i>92 Solar Physics</i> .	

- 71 Acoustics** **143**
Includes sound generation, transmission, and attenuation. For noise pollution see *45 Environment Pollution*. For aircraft noise see also *02 Aerodynamics* and *07 Aircraft Propulsion Propulsion and Power*.
- 72 Atomic and Molecular Physics** **143**
Includes atomic and molecular structure, electron properties, and atomic and molecular spectra. For elementary particle physics see *73 Nuclear Physics*.
- 73 Nuclear Physics** **143**
Includes nuclear particles; and reactor theory. For space radiation see *93 Space Radiation*. For atomic and molecular physics see *72 Atomic and Molecular Physics*. For elementary particle physics see *77 Physics of Elementary Particles and Fields*. For nuclear astrophysics see *90 Astrophysics*.
- 74 Optics** **N.A.**
Includes light phenomena and the theory of optical devices. For lasers see *36 Lasers and Masers*.
- 75 Plasma Physics** **144**
Includes magnetohydrodynamics and plasma fusion. For ionospheric plasmas see *46 Geophysics*. For space plasmas see *90 Astrophysics*.
- 76 Solid-State Physics** **N.A.**
Includes condensed matter physics, crystallography, and superconductivity. For related information see also *33 Electronics and Electrical Engineering* and *36 Lasers and Masers*.
- 77 Physics of Elementary Particles and Fields** **N.A.**
Includes quantum mechanics; theoretical physics; and statistical mechanics. For related information see also *72 Atomic and Molecular Physics*, *73 Nuclear Physics*, and *25 Inorganic, Organic and Physical Chemistry*.

Subject Categories of the Division I. Social and Information Sciences

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

- 80 Social Sciences (General)** **N.A.**
Includes general research topics related to sociology; educational programs and curricula.
- 81 Administration and Management** **145**
Includes management planning and research.

- | | | |
|----|---|------|
| 82 | Documentation and Information Science | 146 |
| | Includes information management; information storage and retrieval technology; technical writing; graphic arts; and micrography. For computer documentation see <i>61 Computer Programming and Software</i> . | |
| 83 | Economics and Cost Analysis | N.A. |
| | Includes cost effectiveness studies. | |
| 84 | Law, Political Science and Space Policy | N.A. |
| | Includes: aviation law; space law and policy; international law; international cooperation; and patent policy. | |
| 85 | Technology Utilization and Surface Transportation | 146 |
| | Includes aerospace technology transfer; urban technology; surface and mass transportation. For related information see <i>03 Air Transportation and Safety</i> , <i>16 Space Transportation and Safety</i> , and <i>44 Energy Production and Conversion</i> . For specific technology transfer applications see also the category where the subject is treated. | |

Subject Categories of the Division J. Space Sciences

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

- | | | |
|----|---|------|
| 88 | Space Sciences (General) | N.A. |
| | Includes general research topics related to the natural space sciences. For specific topics in Space Sciences see <i>categories 89 through 93</i> . | |
| 89 | Astronomy | N.A. |
| | Includes observations of celestial bodies, astronomical instruments and techniques; radio, gamma-ray, x-ray, ultraviolet, and infrared astronomy; and astrometry. | |
| 90 | Astrophysics | N.A. |
| | Includes cosmology; celestial mechanics; space plasmas; and interstellar and interplanetary gases and dust. | |
| 91 | Lunar and Planetary Science and Exploration | N.A. |
| | Includes planetology; selenology; meteorites; comets; and manned and unmanned planetary and lunar flights. For spacecraft design or space stations see <i>18 Spacecraft Design, Testing and Performance</i> . | |
| 92 | Solar Physics | N.A. |
| | Includes solar activity, solar flares, solar radiation and sunspots. For related information see <i>93 Space Radiation</i> . | |

93 Space Radiation

N.A.

Includes cosmic radiation; and inner and outer Earth radiation belts. For biological effects of radiation on plants and animals see *52 Aerospace Medicine*. For theory see *73 Nuclear Physics*.

Subject Categories of the Division K. General

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

99 General

147

Includes aeronautical, astronautical, and space science related histories, biographies, and pertinent reports too broad for categorization; histories or broad overviews of NASA programs such as Apollo, Gemini, and Mercury spacecraft, Earth Resources Technology Satellite (ERTS), and Skylab; NASA appropriations hearings.

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- ❶ 19970001126 NASA Langley Research Center, Hampton, VA USA
- ❷ Water Tunnel Flow Visualization Study Through Poststall of 12 Novel Planform Shapes
- ❸ Gatlin, Gregory M., NASA Langley Research Center, USA Neuhart, Dan H., Lockheed Engineering and Sciences Co., USA;
- ❹ Mar. 1996; 130p; In English
- ❺ Contract(s)/Grant(s): RTOP 505-68-70-04
- ❻ Report No(s): NASA-TM-4663; NAS 1.15:4663; L-17418; No Copyright; Avail: CASI; A07, Hardcopy; A02, Microfiche
- ❼ To determine the flow field characteristics of 12 planform geometries, a flow visualization investigation was conducted in the Langley 16- by 24-Inch Water Tunnel. Concepts studied included flat plate representations of diamond wings, twin bodies, double wings, cutout wing configurations, and serrated forebodies. The off-surface flow patterns were identified by injecting colored dyes from the model surface into the free-stream flow. These dyes generally were injected so that the localized vortical flow patterns were visualized. Photographs were obtained for angles of attack ranging from 10° to 50°, and all investigations were conducted at a test section speed of 0.25 ft per sec. Results from the investigation indicate that the formation of strong vortices on highly swept forebodies can improve poststall lift characteristics; however, the asymmetric bursting of these vortices could produce substantial control problems. A wing cutout was found to significantly alter the position of the forebody vortex on the wing by shifting the vortex inboard. Serrated forebodies were found to effectively generate multiple vortices over the configuration. Vortices from 65° swept forebody serrations tended to roll together, while vortices from 40° swept serrations were more effective in generating additional lift caused by their more independent nature.
- ❽ Author
- ❾ *Water Tunnel Tests; Flow Visualization; Flow Distribution; Free Flow; Planforms; Wing Profiles; Aerodynamic Configurations*

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FAILURE MODES AND EFFECTS ANALYSIS (FMEA)

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19850063766

Combining quantitative and qualitative reasoning in aircraft failure diagnosis

Stengel, R. F., Princeton University, USA; Handelman, D. A.; Jan 1, 1985; 10p; In English; Guidance, Navigation and Control Conference, August 19-21, 1985, Snowmass, CO; See also A85-45876 22-08

Contract(s)/Grant(s): DAAG29-84-K-0048

Report No.(s): AIAA PAPER 85-1905; Copyright; Avail: Issuing Activity

The problem of in-flight failure-origin diagnosis is addressed by combining aspects of analytical redundancy and artificial intelligence theory. The objective is to use the mathematical model designed to simulate aircraft behavior as a supplement to the knowledge used for diagnosis. A method is developed whereby qualitative causal information about a dynamic system is drawn from its model. Based on sensitivities of the equations of motion to worst-case failure modes, a measure of the relative capacity of system elements to affect one another is derived. A diagnosis procedure combining problem reduction and backward-chaining ordered search uses this knowledge to reduce a list of elements capable of failure to a relatively small list of elements suspected of failure. Examples illustrate use of the knowledge base and the problem-solving mechanism that has been developed. Two parameters are found to be crucial to the fault diagnosis: the elapsed time between first detection of a failure and initiation of the diagnosis procedure, and the minimum amount of influence that an element must have on a well-behaved indicator in order to deem the element unfailed.

AIAA

Controllers; Failure Analysis; Failure Modes; Flight Control; In-Flight Monitoring

03 AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; aircraft ground operations; flight safety and hazards; and aircraft accidents. Systems and hardware specific to ground operations of aircraft and to airport construction are covered in 09 Research and Support Facilities (Air). Air traffic control is covered in 04 Aircraft Communications and Navigation. For related information see also 16 Space Transportation and Safety; and 85 Technology Utilization and Surface Transportation.

19860007855 National Aerospace Lab., Informatics Div., Amsterdam, Netherlands

Hardware/software Failure Mode Effect Analysis (FMEA) applied to airplane safety

Vanbaal, J. B. J., National Aerospace Lab., Netherlands; Jul 31, 1984; 9p; In English; 1985 Annual Reliability and Maintainability, 22-24 Jan. 1985, Philadelphia, PA, USA

Report No.(s): NLR-MP-84073-U; B8568107; AD-B095056L; Avail: CASI; A02, Hardcopy; A01, Microfiche

A systematic, analytical methodology for aircraft system safety assessment is explained. A try-out on a software controlled digital avionics system is summarized. Analysis of software components is emphasized. It is concluded that the same methodology can be applied to software and hardware. Conditions that have to be met to perform a successful hardware/software safety assessment are described.

CASI

Airborne/Spaceborne Computers; Aircraft Stability; Certification; Computer Systems Performance; Failure Analysis

19950004035 Rolls-Royce Ltd., Industrial and Marine Gas Turbines., Coventry, West Midlands, UK

The application of aerospace safety and reliability analysis techniques to high speed marine transport

Moore, T. C., Rolls-Royce Ltd., UK; Wilkinson, B., Rolls-Royce Ltd., UK; May 7, 1992; 14p; In English; Safety for High Speed Passenger Craft: The Way Ahead, 7-8 May 1992, London, UK

Report No.(s): PNR-91071; Copyright; Avail: Issuing Activity (European Space Agency (ESA)), Unavail. Microfiche; Limited Reproducibility: More than 20% of this document may be affected by microfiche quality

The application of aerospace safety and reliability techniques to high speed marine craft is discussed, taking into account the following: why failures occur; how safety is demonstrated; what is gained from safety and reliability analyses; the techniques used; and the cost of such analyses. It is concluded that the application of aerospace safety and reliability techniques in their entirety to high speed marine craft would impose an unnecessary burden both in terms of the time scales, complexity of the task, and the associated costs involved. The judicious use of Fault Tree Analysis (FTA), coupled with a Failure Mode Effect Significance Analysis (FMESA) study at a functional rather than at a component level, can provide a cost effective means of demonstrating objectively the safety and reliability levels of a high speed marine craft. This is of vital importance to an industry where the individual craft design production levels are unlikely to be high when compared with the aircraft industry. The use of PC (Personal Computer) based FMEA and FTA software could further reduce the cost, particularly the 'first time' cost.

ESA

Air Transportation; Failure Analysis; Fault Trees; Marine Transportation

19980210315 Brookhaven National Lab., Upton, NY USA

On the safety of aircraft systems: A case study

Martinez-Guridi, G., Brookhaven National Lab., USA; Hall, R. E., Brookhaven National Lab., USA; Fullwood, R. R., Brookhaven National Lab., USA; May 14, 1997; 45p; In English

Contract(s)/Grant(s): DE-AC02-76CH-00016; 95-G-039

Report No.(s): BNL-64946; DE98-002766; No Copyright; Avail: Issuing Activity (Nat'l Technical Information Service (NTIS)), Hardcopy, Microfiche

An airplane is a highly engineered system incorporating control- and feedback-loops which often, and realistically, are non-linear because the equations describing such feedback contain products of state variables, trigonometric or square-root functions, or other types of non-linear terms. The feedback provided by the pilot (crew) of the airplane also is typically non-linear because it has the same mathematical characteristics. An airplane is designed with systems to prevent and mitigate undesired events. If an undesired triggering event occurs, an accident may process in different ways depending on the effectiveness of such systems. In addition, the progression of some accidents requires that the operating crew take corrective action(s), which may modify the configuration of some systems. The safety assessment of an aircraft system typically is carried out using ARP (Aerospace Recommended Practice) 4761 (SAE, 1995) methods, such as Fault Tree Analysis (FTA) and Failure Mode and Effects Analysis (FMEA). Such methods may be called static because they model an aircraft system on its nominal configuration during a mission time, but they do not incorporate the action(s) taken by the operating crew, nor the dynamic behavior (non-linearities) of the system (airplane) as a function of time. Probabilistic Safety Assessment (PSA), also known as Probabilistic Risk Assessment (PRA), has been applied to highly engineered systems, such as aircraft and nuclear power plants. PSA encompasses a wide variety of methods, including event tree analysis (ETA), FTA, and common-cause analysis, among others. PSA should not be confused with ARP 4761's proposed PSSA (Preliminary System Safety Assessment); as its name implies, PSSA is a preliminary assessment at the system level consisting of FTA and FMEA.

DOE

Failure Analysis; Safety Factors; Feedback Control; Aeronautics

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes all modes of communication with and between aircraft; air navigation systems (satellite and ground based); and air traffic control. For related information see also 06 Avionics and Aircraft Instrumentation; 17 Space Communications; Spacecraft Communications, Command and Tracking, and 32 Communications and Radar.

19830016221 Pailen-Johnson Associates, Inc., McLean, VA, USA

Failure Modes, Effects and Criticality Analysis (FMECA) of type AN/GRN-27 (V) instrument landing system with travelling-wave localizer antenna *Final Report*

Pappas, G., Pailen-Johnson Associates, Inc., USA; Pendleton, R., Pailen-Johnson Associates, Inc., USA; Feb 1, 1983; 142p; In English

Contract(s)/Grant(s): DTFA01-82-Y-10537

Report No.(s): DOT/FAA/PM-83/18; Avail: CASI; A07, Hardcopy; A02, Microfiche

A Failure Modes, Effects and Criticality Analysis (FMECA) is used to determine, for the AN/GRN-27(V), the probability of radiation of a hazardous signal and the probability of a loss of signal. This analysis is based on the FMECA performed on the Texas instruments, incorporated Mark III ILS (Report No. FAA-RD-73-111), modified to reflect the differences between the Mark III and the GRN-27. The methodology considers the effects of all failures of functionally distinct circuits which can result in potentially hazardous failure modes. Possible modifications to operating procedures and equipment are considered with respect to meeting the proposed Level 3 and Level 4 reliability levels. The reliability resulting from such improvements is calculated and description of recommended improvements is included. Facility Maintenance Logs for the calendar year 1981 from GRN-27 facilities are analyzed and correlated with the theoretical calculations.

CASI

Antennas; Failure Analysis; Failure Modes; Instrument Landing Systems; Reliability Analysis

19860015207 Draper (Charles Stark) Lab., Inc., Cambridge, MA, USA

The evaluation of the OSGLR algorithm for restructurable controls *Final Report, Dec. 1985 - Apr. 1986*

Bonnice, W. F., Draper (Charles Stark) Lab., Inc., USA; Wagner, E., Draper (Charles Stark) Lab., Inc., USA; Hall, S. R., Draper (Charles Stark) Lab., Inc., USA; Motyka, P., Draper (Charles Stark) Lab., Inc., USA; Mar 1, 1986; 177p; In English

Contract(s)/Grant(s): NAS1-17556

Report No.(s): NASA-CR-178083; NAS 1.26:178083; CSDL-R-1849; Avail: CASI; A09, Hardcopy; A02, Microfiche

The detection and isolation of commercial aircraft control surface and actuator failures using the orthogonal series generalized likelihood ratio (OSGLR) test was evaluated. The OSGLR algorithm was chosen as the most promising algorithm based on a preliminary evaluation of three failure detection and isolation (FDI) algorithms (the detection filter, the generalized likelihood ratio test, and the OSGLR test) and a survey of the literature. One difficulty of analytic FDI techniques and the OSGLR algorithm in particular is their sensitivity to modeling errors. Therefore, methods of improving the robustness of the algorithm were examined with the incorporation of age-weighting into the algorithm being the most effective approach, significantly reducing the sensitivity of the algorithm to modeling errors. The steady-state implementation of the algorithm based on a single cruise linear model was evaluated using a nonlinear simulation of a C-130 aircraft. A number of off-nominal no-failure flight conditions including maneuvers, nonzero flap deflections, different turbulence levels and steady winds were tested. Based on the no-failure decision functions produced by off-nominal flight conditions, the failure detection performance at the nominal flight condition was determined. The extension of the algorithm to a wider flight envelope by scheduling the linear models used by the algorithm on dynamic pressure and flap deflection was also considered. Since simply scheduling the linear models over the entire flight envelope is unlikely to be adequate, scheduling of the steady-state implementation of the algorithm was briefly investigated.

CASI

Aircraft Control; Algorithms; Failure Analysis; Failure Modes; Likelihood Ratio

19980184836

Single points of failure in complex aviation CNS systems and possible options for reducing the exposure to them

Asbury, Michael J. A., National Air Traffic Services, UK; Johannessen, Rolf, BNR Europe, Ltd., UK; 1994, pp. 319-330; In English; Copyright; Avail: Aeroplus Dispatch

The paper discusses the strength and weakness of redundancy in satellite based Communication, Navigation, and Surveillance (CNS) systems, which are planned by the ICAO to be an integral part of the future air navigation system, and makes a comparison with today's terrestrial based systems. Particular attention is drawn to the importance of avoiding points of failure in future CNS systems, which in conventional terrestrial aids are avoided by redundancy. However, as the software content of navigation receivers increases, the overall system reliability may become dominated by software performance. Software bugs initiated by conditions external to the aircraft can lead to failures that affect both receivers in a duplicated pair. Steps that can be taken to reduce software failures are discussed.

AIAA

Failure Analysis; Civil Aviation; Avionics; Failure Modes

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes all stages of design of aircraft and aircraft structures and systems. Also includes aircraft testing, performance, and evaluation, and aircraft and flight simulation technology. For related information, see also 18 Spacecraft Design, Testing and Performance and 39 Structural Mechanics. For land transportation vehicles, see 85 Technology Utilization and Surface Transportation.

19910012801 Aeronautical Research Labs., Melbourne, Australia

Fatigue testing of the MK3 mod0 2000 lb bail lugs: Test report *Aircraft Systems Project Document*

Jaeger, J. L., Aeronautical Research Labs., Australia; Aug 1, 1990; 20p; In English

Report No.(s): AD-A230858; ARL/SYS-PD-003; DODA-AR-006-071; Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

This report details the procedure and results obtained for fatigue tests conducted on 2000 lb bail lugs in accordance with MIL-HDBK-5E. The bail lugs were mounted into the testing rig and subjected to selected levels of cyclic loading until failure occurred. For each of the two selected stress ratios of $R = 0.1$ and 0.6 , four to six lugs were tested in order to establish the general shape of the S/N curves. Once the general fatigue curves were established, replicate tests were conducted at a minimum of three evenly spaced maximum load levels, in order to statistically define the fatigue curves. The number of lugs tested at each load level depended on the variability of the results. The output from the calibrated load cell placed in series with the bail lug was monitored visually on an oscilloscope to ensure correct loading of the lugs. A frequency counter was used to count the number of cycles that the lugs were subjected to. Each test item was subjected to a visual examination at the end of the test to note the failure mode. The test details and results are presented.

K.S.

Cyclic Loads; Failure Analysis; Failure Modes; Fatigue Tests; Lugs; Stress Ratio

19960048379 Purdue Research Foundation, Dept. of Engineering., IN USA

Fatigue Failure Analysis of Polycarbonate Transparencies in Different Environmental Conditions *Final Report, 18 May 1992 - 1 Oct. 1994*

Kin, Yulian B., Purdue Research Foundation, USA; Dec. 1994; 55p; In English

Contract(s)/Grant(s): F33615-92-C-3403; AF Proj. 2402

Report No.(s): AD-A305093; WL-TR-94-3157; No Copyright; Avail: CASI; A04, Hardcopy; A01, Microfiche

The investigation completed under the existing contract determines the extruded polycarbonate fatigue life dependency on elevated and cooling temperatures. The specimens were manufactured from the 1/2-inch flat polycarbonate sheet which is used as a structural component in laminates for some F-16 aircraft canopies. The results of the investigation showed that the elevated temperature is extremely dangerous. Fatigue lives of the specimens tested on different combinations of load and elevated temperature levels were always significantly (up to 10 times) less compared to those tested under the same load levels at room temperature. The surface topography failure modes also were different: ductile under room temperature and brittle under elevated temperatures. The investigations under cooling temperatures proved that the resistance to fatigue failure is substantially greater than that for room temperature.

DTIC

Canopies; Failure Analysis; Failure Modes; Fatigue Life; High Temperature; Room Temperature; Polycarbonates; Extruding; Laminates; Structural Analysis

19980129404

Damage tolerance and failure analysis of a composite geodesically stiffened compression panel

Rouse, Marshall, NASA Langley Research Center, USA; Ambur, Damodar R., NASA Langley Research Center, USA; *Journal of Aircraft*; Jul. 1996; ISSN 0021-8669; Volume 33, no. 3, pp. 582-588; In English; Copyright; Avail: Aeroplus Dispatch

A geodesically stiffened continuous-filament composite structural concept has been designed for a transport aircraft fuselage application and fabricated using an automated manufacturing process. Both large panels and element specimens derived from these panels have been experimentally and analytically investigated in axial compression to understand their buckling, postbuckling, and failure responses. The primary failure mode for this structural concept is skin-stiffener separation in the skin postbuckling load range. The large panels are subjected to low-speed impact damage and tested to failure in axial compression to evaluate the damage tolerance of this structural concept. These results suggest that damage to the stiffener and a stiffener intersection point from the skin side do not influence the failure load or failure mode of this structural concept. Nonlinear finite element analysis using a detailed element specimen model indicates that failure of this specimen may have initiated at the

skin-stiffener flange region close to the stiffener intersection. When the skin is in the postbuckling range at four times its initial buckling load, the interlaminar shear stress concentrations at a region where the stiffener makes a 20-deg turn away from the stiffener intersection seem to initiate panel failure.

Author (AIAA)

Aircraft Structures; Axial Compression Loads; Failure Analysis; Composite Structures; Rigid Structures; Failure Modes

06

AVIONICS AND AIRCRAFT INSTRUMENTATION

Includes all stages of design of aircraft and aircraft structures and systems. Also includes aircraft testing, performance, and evaluation, and aircraft and flight simulation technology. For related information, see also 18 Spacecraft Design, Testing and Performance and 39 Structural Mechanics. For land transportation vehicles, see 85 Technology Utilization and Surface Transportation.

19830023331 Honeywell, Inc., Avionics Div., Minneapolis, MN, USA

Demonstration Advanced Avionics System (DAAS), phase 1 *Final Contractor Report*

Bailey, A. J., Honeywell, Inc., USA; Bailey, D. G., Honeywell, Inc., USA; Gaabo, R. J., Honeywell, Inc.; Lahn, T. G., Honeywell, Inc.; Larson, J. C., Honeywell, Inc.; Peterson, E. M., Honeywell, Inc.; Schuck, J. W., Honeywell, Inc.; Rodgers, D. L., King Radio Corp.; Wroblewski, K. A., King Radio Corp.; Apr 1, 1981; 161p; In English

Contract(s)/Grant(s): NAS2-10021

Report No.(s): NASA-CR-166503; NAS 1.26:166503; Avail: CASI; A08, Hardcopy; A02, Microfiche

Demonstration advanced avionics system (DAAS) function description, hardware description, operational evaluation, and failure mode and effects analysis (FMEA) are provided. Projected advanced avionics system (PAAS) description, reliability analysis, cost analysis, maintainability analysis, and modularity analysis are discussed.

CASI

Avionics; Failure Modes; Hardware

19870059453

Culprits causing avionics equipment failures

Wong, Kam L.; Quart, Irving, Kambea Industries, Inc., USA; Kallis, James M., Hughes Aircraft Co., USA; Burkhard, Alan H., USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, USA; Jan 1, 1987; 6p; In English; See also A87-46701; Copyright; Avail: Issuing Activity

An examination of industrial and military failure data is performed to determine the major locations and types of defects causing avionics field failures. Field failures were found to occur primarily in devices containing semiconductors, with discrete capacitors and discrete resistors being less frequent locations of failures. Connectors, relays, filters, and magnetic devices were found to be insignificant contributors to failures, while solder joints and printed circuit boards are believed to have a significant number of failures. More than a dozen types of defects, each contributing to a small fraction of the failures, have been identified.

AIAA

Avionics; Failure Analysis; Failure Modes; Life (Durability); Prediction Analysis Techniques; Printed Circuits

19960010912 University of Southern Colorado, Pueblo, CO, USA

Investigation of advanced failure modes analyses and tests for Harrier digital avionics *Final Report, 1 Oct. 1985 - 30 Sep. 1995*

Dunn, William, Jr., University of Southern Colorado, USA; Lesiak, Casmir, University of Southern Colorado, USA; Sep 30, 1995; 4p; In English

Contract(s)/Grant(s): NCC2-373

Report No.(s): NASA-CR-199707; NAS 1.26:199707; NIPS-95-06022; Avail: CASI; A01, Hardcopy; A01, Microfiche

Work during the course of the above agreement resulted in eight open-literature publications. Cumulated references to these publications follows this general summary. Primary USC effort under the grant was to collaborate with NASA-Ames scientists in two flight research programs: the V/STOL Systems Research Aircraft (VSRA) Project and the Ames RASCAL Project, an Arm Blackhawk helicopter modified for advanced flight research. Effort supporting the VSRA Project included: (1) development of methods for performing quantitative risk assessment of airborne systems and ground facilities controls; (2) preparation of a VSRA FMEA and Hazard Analysis (to assist in fault simulation); (3) development of navigation algorithms; (4) development of simulation models to be used in the VSRA Development Facility; (5) derivation of plant models for the aircraft (A YAV-8B); (6)

development of a set of automated data gathering tools to support the general checkout of the simulation and the failure mode testing; (7) development of menu-oriented methods for generating failure mode test data sets; and (8) assistance in development of a programmable display unit for driving a heads-up display unit. Effort supporting RASCAL included: (1) development of a helmet-mounted display; and (2) assistance in developing advance terrain-following and Nap-of Earth (NOE) algorithms.

Derived from text

Algorithms; Applications Programs (Computers); Avionics; Digital Electronics; Failure Modes; Harrier Aircraft; In-Flight Monitoring; Navigation Aids; Research Aircraft; Research Projects; Software Engineering; V/STOL Aircraft

19990050194

BITE is not the answer (but what is the question?)

Carson, Ronald S., Boeing Co., USA; 1998, pp. B41-1 (8 p.); In English; Copyright; Avail: AIAA Dispatch

We propose a methodology for performing line maintenance that is less dependent on the scope of built-in-test than is traditionally thought to be necessary, and, when followed scrupulously, results in low faults found ratio (NFF) rates. The method flows out of the failure modes and effects analysis (FMEA), by identifying and correlating the effects of failure (including annunciated test results and observables, such as loss or degradation of function). by working 'backward' from the failure effects using the analysis, the most probable source of failure can be identified. We analyze an extensive cabin system with audio and video distribution, and show that the NFF rate is relatively insensitive to the actual amount of built-in-test equipment (BITE), and very sensitive to following the recommended procedures for isolating a failure and replacing suspected units. The question is not 'How do I find out what is failed?', which is the focus of BITE, but is 'What must be done to restore full functionality?'

Author (AIAA)

Passenger Aircraft; Test Equipment; Fault Detection; Aircraft Maintenance; Failure Modes

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and onboard auxiliary power plants for aircraft. For related information see also 20 Spacecraft Propulsion and Power, 28 Propellants and Fuels, and 44 Energy Production and Conversion.

19830022418 Franklin Research Center, Philadelphia, PA, USA

Modal analysis as a tool in the evaluation of a turbine wheel failure

Moffa, A. L., Franklin Research Center, USA; Leon, R. L., Franklin Research Center, USA; Shock and Vibration Inform. Center The Shock and Vibration Bull., No. 52. Part 1; May 1, 1982, pp. p 101-123; In English; See also N83-30684 19-31; Avail: CASI; A03, Hardcopy; A02, Microfiche

Modal Analysis is a viable tool in the investigation of turbine wheel failures. With the advent of the portable dual channel analyzer, and impact excitation techniques, modal data can be accurately and easily taken right at the plant site. Armed with this additional information, a better estimate of the actual failure mode can be made. Following a turbine failure, the system is taken out of service, the failed parts are metallurgically analyzed, and the turbine is either repaired or replaced. It is during this time period that modal testing is performed and its evaluation used to aid in the failure analysis.

S.L.

Failure Analysis; Failure Modes; Modal Response; Turbine Wheels

19920013277 NASA Lewis Research Center, Cleveland, OH, USA

Life prediction technologies for aeronautical propulsion systems

McGaw, Michael A., NASA Lewis Research Center, USA; Aeropropulsion 1987; Feb 1, 1990, pp. p 129-139; In English; See also N92-22510 13-07; Avail: CASI; A03, Hardcopy; A04, Microfiche

Fatigue and fracture problems continue to occur in aeronautical gas turbine engines. Components whose useful life is limited by these failure modes include turbine hot-section blades, vanes, and disks. Safety considerations dictate that catastrophic failures be avoided, while economic considerations dictate that catastrophic failures be avoided, while economic considerations dictate that noncatastrophic failures occur as infrequently as possible. Therefore, the decision in design is making the tradeoff between engine performance and durability. LeRC has contributed to the aeropropulsion industry in the area of life prediction technology for over 30 years, developing creep and fatigue life prediction methodologies for hot-section materials. At the present time, emphasis is being placed on the development of methods capable of handling both thermal and mechanical fatigue under severe environments. Recent accomplishments include the development of more accurate creep-fatigue life prediction methods such as

the total strain version of LeRC's strain-range partitioning (SRP) and the HOST-developed cyclic damage accumulation (CDA) model. Other examples include the development of a more accurate cumulative fatigue damage rule - the double damage curve approach (DDCA), which provides greatly improved accuracy in comparison with usual cumulative fatigue design rules. Other accomplishments in the area of high-temperature fatigue crack growth may also be mentioned. Finally, we are looking to the future and are beginning to do research on the advanced methods which will be required for development of advanced materials and propulsion systems over the next 10-20 years.

CASI

Aircraft Engines; Engine Parts; Failure Analysis; Failure Modes; Fatigue (Materials); Gas Turbine Engines; Life (Durability); Prediction Analysis Techniques

19940010368 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, USA

An improved approach for flight readiness certification: Probabilistic models for flaw propagation and turbine blade failure. Volume 1: Methodology and applications

Moore, N. R., Jet Propulsion Lab., California Inst. of Tech., USA; Ebbeler, D. H., Jet Propulsion Lab., California Inst. of Tech., USA; Newlin, L. E., Jet Propulsion Lab., California Inst. of Tech., USA; Sutharshana, S., Jet Propulsion Lab., California Inst. of Tech., USA; Creager, M., Jet Propulsion Lab., California Inst. of Tech., USA; Dec 30, 1992; 200p; In English

Contract(s)/Grant(s): NAS7-918; RTOP 553-02-01

Report No.(s): NASA-CR-194496; JPL-PUBL-92-32-VOL-1; NAS 1.26:194496; Avail: CASI; A09, Hardcopy; A03, Microfiche

An improved methodology for quantitatively evaluating failure risk of spaceflight systems to assess flight readiness and identify risk control measures is presented. This methodology, called Probabilistic Failure Assessment (PFA), combines operating experience from tests and flights with analytical modeling of failure phenomena to estimate failure risk. The PFA methodology is of particular value when information on which to base an assessment of failure risk, including test experience and knowledge of parameters used in analytical modeling, is expensive or difficult to acquire. The PFA methodology is a prescribed statistical structure in which analytical models that characterize failure phenomena are used conjointly with uncertainties about analysis parameters and/or modeling accuracy to estimate failure probability distributions for specific failure modes. These distributions can then be modified, by means of statistical procedures of the PFA methodology, to reflect any test or flight experience. State-of-the-art analytical models currently employed for designs failure prediction, or performance analysis are used in this methodology. The rationale for the statistical approach taken in the PFA methodology is discussed, the PFA methodology is described, and examples of its application to structural failure modes are presented. The engineering models and computer software used in fatigue crack growth and fatigue crack initiation applications are thoroughly documented.

Author (revised)

Failure Analysis; Failure Modes; Probability Theory; Quality Control; Reliability Engineering; Spacecraft Design; Statistical Analysis; Structural Failure

19940010369 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, USA

An improved approach for flight readiness certification: Probabilistic models for flaw propagation and turbine blade failure. Volume 2: Software documentation

Moore, N. R., Jet Propulsion Lab., California Inst. of Tech., USA; Ebbeler, D. H., Jet Propulsion Lab., California Inst. of Tech., USA; Newlin, L. E., Jet Propulsion Lab., California Inst. of Tech., USA; Sutharshana, S., Jet Propulsion Lab., California Inst. of Tech., USA; Creager, M., Jet Propulsion Lab., California Inst. of Tech., USA; Dec 30, 1992; 507p; In English

Contract(s)/Grant(s): NAS7-918; RTOP 553-02-01

Report No.(s): NASA-CR-194497; JPL-PUBL-92-32-VOL-2; NAS 1.26:194497; Avail: CASI; A22, Hardcopy; A04, Microfiche

An improved methodology for quantitatively evaluating failure risk of spaceflights systems to assess flight readiness and identify risk control measures is presented. This methodology, called Probabilistic Failure Assessment (PFA), combines operating experience from tests and flights with analytical modeling of failure phenomena to estimate failure risk. The PFA methodology is of particular value when information on which to base an assessment of failure risk, including test experience and knowledge of parameters used in analytical modeling, is expensive or difficult to acquire. The PFA methodology is a prescribed statistical structure in which analytical models that characterize failure phenomena are used conjointly with uncertainties about analysis parameters and/or modeling accuracy to estimate failure probability distributions for specific failure modes. These distributions can then be modified, by means of statistical procedures of the PFA methodology, to reflect any test or flight experience. State-of-the-art analytical models currently employed for design, failure prediction, or performance analysis are used in this methodology. The rationale for the statistical approach taken in the PFA methodology is discussed, the PFA methodology is

described, and examples of its application to structural failure modes are presented. The engineering models and computer software used in fatigue crack growth and fatigue crack initiation applications are thoroughly documented.

Author (revised)

Failure Analysis; Failure Modes; Probability Theory; Quality Control; Reliability Engineering; Spacecraft Design; Statistical Analysis; Structural Failure

19950004033 Rolls-Royce Ltd., Industrial and Marine Gas Turbines., Coventry, West Midlands, UK

The reliability of aero-derived marine gas turbines

Moore, Tim C., Rolls-Royce Ltd., UK; Wilkinson, Brian, Rolls-Royce Ltd., UK; Jan 1, 1992; 17p; In English; High Speed Surface Craft Conference, Jan. 1992, London, UK

Report No.(s): PNR-90982; Copyright; Avail: Issuing Activity (European Space Agency (ESA)), Unavail. Microfiche; Limited Reproducibility: More than 20% of this document may be affected by microfiche quality

An overview of work carried out to assess the safety and reliability of the Marine Spey, a marine propulsion gas turbine unit, is reported. The question of the limit of safety inherent in reliability of an aeroengine is considered. Failure probabilities are defined both qualitatively and quantitatively, and it is shown how the combination of failure effect category and probability rank defines the risk level. Means of assessing the capability of a design to comply to the reliability standards are addressed. These can take the form of a Failure Mode Effects Analysis (FMEA), Failure Mode Effect Criticality Analysis (FMECA), or a Failure Mode Effect Systems Analysis (FMESA). The latter investigates the significance of a system or subsystem failure on the operation of the overall plant. The use of FMESA studies on aero derived marine gas turbines is considered, and the safety and reliability in fast ferries is discussed. Modern FEA techniques, which include the Fault Tree Analysis (FTA) used to assess safety, control and protection system reliability, are considered.

ESA

Engine Design; Engine Failure; Failure Analysis; Gas Turbine Engines; Marine Propulsion; Reliability; System Failures

19980009044 Naval Air Warfare Center, Aircraft Div., Trenton, NJ USA

Evaluation of Lightweight Material Concepts for Aircraft Turbine Engine Rotor Failure Protection *Final Report*

Le, D. D., Naval Air Warfare Center, USA; Jul. 1997; 84p; In English

Contract(s)/Grant(s): DTFA03-95-X-90010; DTFA03-88-A-00029

Report No.(s): PB97-203129; AIR-447200P; No Copyright; Avail: CASI; A05, Hardcopy; A01, Microfiche

Results of the evaluation of lightweight materials for aircraft turbine engine rotor failure protection are presented in the report. Phase 1 was an evaluation of a group of composite materials which could possibly contain the impact energies of 1.0×10^6 inch-pounds generated by T53 rotor fragments. Phase 2 refined system composition and weight of the optimum materials selected from phase 1 and determined their performance under elevated temperatures. Based on the results of phase 1, the aluminum lined fiberglass is the best system, so far. The Aramid system with an aluminum liner performed almost as effective as aluminum lined fiberglass under ambient conditions. Dry Kevlar performed better than Kevlar impregnated with phenolic resin. Under elevated temperatures, the performances of the aluminum lined fiberglass system, based on energy per weight and thickness, reduced by 50 and 33% respectively. Fabric composite systems absorbed the kinetic energy of fragments through elastic deformation and interlaminated shear of composite layers.

NTIS

Aircraft Construction Materials; Aircraft Engines; Rotors; Failure Modes; Fragments; Failure Analysis; Fiber Composites; Engine Failure; Gas Turbine Engines

19980074159

Study of an FMEA automation technique for an airborne power system

Shen, Songhua, Beijing Univ. of Aeronautics and Astronautics, China; Li, Ying, Beijing Univ. of Aeronautics and Astronautics, China; Kang, Rui, Beijing Univ. of Aeronautics and Astronautics, China; Beijing University of Aeronautics and Astronautics, Journal; Dec. 1997; ISSN 1001-5965; Volume 23, no. 6, pp. 805-809; In Chinese; Copyright; Avail: AIAA Dispatch

The authors present an automatic quantitative analysis method of failure modes and effects analysis (FMEA) with system transient simulation in the system design stage, with an airborne power system considered as a case in point. By the use of the method, every possible failure mode of the elements and devices in the system is accounted for in the system transient model. Simulation results on the failure states are obtained, and the serious level of every failure mode effect is determined as a numerical quantity.

Author (AIAA)

Failure Modes; Automatic Control; Aircraft Power Supplies

19990070400 Orenda Aerospace Corp., Advanced Materials and Energy Systems, Gloucester, Ontario Canada

Development of a Qualification Methodology for Advanced Gas Turbine Engine Repairs/Reworks

Patnaik, P. C., Orenda Aerospace Corp., Canada; Thamburaj, R., Orenda Aerospace Corp., Canada; March 1999; 11p; In English; See also 19990070390; Copyright Waived; Avail: CASI; A03, Hardcopy; A02, Microfiche

In this paper the engine and component qualification test requirements with specific application to component repairs/reworks of Civilian and US military specifications and standards for turboshaft, turboprop, turbofan and turbojet engines have been reviewed and a methodology developed. Having identified that repairs were feasible and cost beneficial, a review of civil and military airworthiness guidance was conducted in order to identify a process that would ensure that a high state of airworthiness was maintained and which would easily translate to civil requirements. Failure mode, effects and criticality analysis, as a reliability analysis tool, for Gas Turbines has been developed for component repair/reworks. As part of the development of a FMECA engineering tool, a specific procedure has been developed for performing FMECA on various type of gas turbines, including turbojet, turbofan, turboshaft and turboprop engines. According to the specification established by Orenda and GasTOPS (the sub-contactor), the developed software contains the following: (1) System definition with iconic display, (2) Complete FMEA capable to use either hardware or functional approach or a combination of both, (3) Complete CA capability with either qualitative or quantitative method and, (4) FMECA report format to help the users to generate a complete FMECA report. The software is a generic FMECA tool for the applications to various types of aircraft engine systems, including turbojet, turbofan, turboshaft turboprop and etc. The test of the software has been carried out by both GasTOPS and Orenda using a set of F-404 data. In terms of a Qualification Methodology Development, coupon, component and full scale engine testing are required by all standards to show compliance with the structural integrity and durability requirements (e.g. low cycle fatigue, high cycle fatigue, creep, vibration, containment) for gas path structural components under different environmental operating conditions. An Engine Repair Structural Integrity Program (ERSIP) Standard was proposed which is an integral part of the Qualification Methodology for engine component repairs. The ERSIP Standard incorporates the damage tolerance concept as required in MIL-STD-1783 (USAF-Engine Structural Integrity Program (ENSIP)). The ENSIP Standard establishes the repair development and repair qualification tests to ensure structural integrity and performance throughout the repair life cycle.

Author

Engine Tests; Equipment Specifications; Failure Analysis; Turbojet Engines; Turboprop Engines; Turboshafts; Structural Failure; Maintenance; Life (Durability)

12

ASTRONAUTICS (GENERAL)

Includes general research topics related to space flight and manned and unmanned space vehicles, platforms or objects launched into, or assembled in, outer space; and related components and equipment. Also includes manufacturing and maintenance of such vehicles or platforms. For specific topics in astronautics see categories 13 through 20. For extraterrestrial exploration, see 91 Lunar and Planetary Science and Exploration.

19870058726 Rockwell International Corp., Canoga Park, CA, USA

Concepts for space maintenance of OTV engines

Martinez, A., Rockwell International Corp., USA; Hines, B. D., Rockwell International Corp., USA; Erickson, C. M., Rockwell International Corp., USA; Aug 1, 1986; 13p; In English

Contract(s)/Grant(s): NAS3-23773; Avail: Issuing Activity

In this paper, concepts for space maintainability of Orbital Transfer Vehicles engines are examined. An engine design is developed which is driven by space maintenance requirements and by a Failure Modes and Effects Analysis (FMEA). Modularity within the engine is shown to offer cost benefits and improved space maintenance capabilities. Space-operable disconnects are conceptualized for both engine change-out and for module replacement. Through FME mitigation the modules are conceptualized to contain the most often replaced engine components. A preliminary space maintenance plan is developed around a Controls and Condition Monitoring system using advanced sensors, controls, and conditioning monitoring concepts.

AIAA

Orbit Transfer Vehicles; Orbital Servicing; Rocket Engine Design; Spacecraft Maintenance

19920011291 NASA, Washington, DC, USA

Mission safety evaluation report for STS-35: Postflight edition

Hill, William C., NASA, USA; Finkel, Seymour I., NASA, USA; Mar 15, 1991; 203p; In English

Report No.(s): NASA-TM-107779; NAS 1.15:107779; Avail: CASI; A10, Hardcopy; A03, Microfiche

Space Transportation System 35 (STS-35) safety risk factors that represent a change from previous flights that had an impact on this flight, and factors that were unique to this flight are discussed. While some changes to the safety risk baseline since the

previous flight are included to highlight their significance in risk level change, the primary purpose is to insure that changes which were too late too include in formal changes through the Failure Modes and Effects Analysis/Critical Items List (FMEA/CIL) and Hazard Analysis process are documented along with the safety position, which includes the acceptance rationale.

CASI

Failure Modes; Hazards; Risk; Safety; Safety Factors; Space Transportation System; Space Transportation System Flights

19950020973 California Univ., Computer Science Dept., Davis, CA, USA

Comprehension and retrieval of failure cases in airborne observatories

Alvarado, Sergio J., California Univ., USA; Mock, Kenrick J., California Univ., USA; NASA. Goddard Space Flight Center, The 1995 Goddard Conference on Space Applications of Artificial Intelligence and Emerging Information Technologies; May 1, 1995, pp. p 237-251; In English; See also N95-27375 09-63

Contract(s)/Grant(s): NCA2-721; Avail: CASI; A03, Hardcopy; A03, Microfiche

This paper describes research dealing with the computational problem of analyzing and repairing failures of electronic and mechanical systems of telescopes in NASA's airborne observatories, such as KAO (Kuiper Airborne Observatory) and SOFIA (Stratospheric Observatory for Infrared Astronomy). The research has resulted in the development of an experimental system that acquires knowledge of failure analysis from input text, and answers questions regarding failure detection and correction. The system's design builds upon previous work on text comprehension and question answering, including: knowledge representation for conceptual analysis of failure descriptions, strategies for mapping natural language into conceptual representations, case-based reasoning strategies for memory organization and indexing, and strategies for memory search and retrieval. These techniques have been combined into a model that accounts for: (a) how to build a knowledge base of system failures and repair procedures from descriptions that appear in telescope-operators' logbooks and FMEA (failure modes and effects analysis) manuals; and (b) how to use that knowledge base to search and retrieve answers to questions about causes and effects of failures, as well as diagnosis and repair procedures. This model has been implemented in FANSYS (Failure ANalysis SYstem), a prototype text comprehension and question answering program for failure analysis.

Author

Failure Analysis; Knowledge Representation; Maintenance; Spaceborne Telescopes; System Failures

14

GROUND SUPPORT SYSTEMS AND FACILITIES (SPACE)

Includes launch complexes, research and production facilities; ground support equipment, e.g., mobile transporters; and test chambers and simulators. Also includes extraterrestrial bases and supporting equipment. For related information see also 09 Research and Support Facilities (Air).

19890027964 NASA Marshall Space Flight Center, Huntsville, AL, USA

Starr - An expert system for failure diagnosis in a space based power system

Walls, Bryan, NASA Marshall Space Flight Center, USA; Jan 1, 1988; 4p; In English; 23rd; 1988 IECEC, July 31-Aug. 5, 1988, Denver, CO, USA; See also A89-15176 04-44; Copyright; Avail: Issuing Activity

Starr, a prototype expert system, is designed to monitor and model a space power system, recognize problem states, identify the failure, and recommend the proper action to be taken. The system was modeled on the autonomously managed power system (AMPS) breadboard at NASA-Marshall. An object-oriented approach was used for the Starr model.

AIAA

Expert Systems; Failure Analysis; Failure Modes; Spacecraft Power Supplies

16

SPACE TRANSPORTATION AND SAFETY

Includes passenger and cargo space transportation, e.g., shuttle operations; and space rescue techniques. For related information, see also 03 Air Transportation and Safety and 15 Launch Vehicles and Launch Vehicles, and 18 Spacecraft Design, Testing and Performance. For space suits, see 54 Man/System Technology and Life Support.

19900001597 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the manned maneuvering unit

Bailey, P. S., McDonnell-Douglas Astronautics Co., USA; Nov 21, 1986; 175p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185565; NAS 1.26:185565; REPT-1.0-WP-VA86001-09; Avail: CASI; A08, Hardcopy; A02, Microfiche

Results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items (PCIs). To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Manned Maneuvering Unit (MMU) hardware. The MMU is a propulsive backpack, operated through separate hand controllers that input the pilot's translational and rotational maneuvering commands to the control electronics and then to the thrusters. The IOA analysis process utilized available MMU hardware drawings and schematics for defining hardware subsystems, assemblies, components, and hardware items. Final levels of detail were evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the worst case severity of the effect for each identified failure mode. The IOA analysis of the MMU found that the majority of the PCIs identified are resultant from the loss of either the propulsion or control functions, or are resultant from inability to perform an immediate or future mission. The five most severe criticalities identified are all resultant from failures imposed on the MMU hand controllers which have no redundancy within the MMU.

CASI

Controllers; Failure Modes; Manned Maneuvering Units; Propulsive Efficiency; Space Shuttle Orbiters; Spacecraft Reliability

19900001598 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support, Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the electrical power generation/fuel cell powerplant subsystem FMEA/CIL

Brown, K. L., McDonnell-Douglas Astronautics Co., USA; Bertsch, P. J., McDonnell-Douglas Astronautics Co., USA; Mar 20, 1987; 119p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185562; NAS 1.26:185562; REPT-1.0-WP-VA86001-24; Avail: CASI; A06, Hardcopy; A02, Microfiche

Results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Electrical Power Generation/Fuel Cell Powerplant (EPG/FCP) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the proposed Post 51-L NASA FMEA/CIL baseline. A resolution of each discrepancy from the comparison was provided through additional analysis as required. This report documents the results of that comparison for the Orbiter EPG/FCP hardware.

CASI

Failure Modes; Fuel Cells; Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability

19900001599 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support, Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the electrical power generation/fuel cell powerplant subsystem

Brown, K. L., McDonnell-Douglas Astronautics Co., USA; Bertsch, P. J., McDonnell-Douglas Astronautics Co., USA; Dec 5, 1986; 100p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185561; NAS 1.26:185561; REPT-1.0-WP-VA86001-10; Avail: CASI; A05, Hardcopy; A02, Microfiche

Results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Orbiter Electrical Power Generation (EPG)/Fuel Cell Powerplant (FCP) hardware. The EPG/FCP hardware is required for performing functions of electrical power generation and product water distribution in the Orbiter. Specifically, the EPG/FCP hardware consists of the following divisions: (1) Power Section Assembly (PSA); (2) Reactant Control Subsystem (RCS); (3) Thermal Control Subsystem (TCS); and (4) Water Removal Subsystem (WRS). The IOA analysis process utilized available EPG/FCP hardware drawings and schematics for defining hardware assemblies, components, and hardware items. Each level of hardware

was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode.

CASI

Controllers; Failure Modes; Fuel Cells; Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability

19900001600 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the rudder/speed brake subsystem

Wilson, R. E., McDonnell-Douglas Astronautics Co., USA; Riccio, J. R., McDonnell-Douglas Astronautics Co., USA; Nov 21, 1986; 70p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185560; NAS 1.26:185560; REPT-1.0-WP-VA86001-04; Avail: CASI; A04, Hardcopy; A01, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The independent analysis results for the Orbiter Rudder/Speedbrake Actuation Mechanism is documented. The function of the Rudder/Speedbrake (RSB) is to provide directional control and to provide a means of energy control during entry. The system consists of two panels on a vertical hinge mounted on the aft part of the vertical stabilizer. These two panels move together to form a rudder but split apart to make a speedbrake. The Rudder/Speedbrake Actuation Mechanism consists of the following elements: (1) Power Drive Unit (PDU) which is composed of hydraulic valve module and a hydraulic motor-powered gearbox which contains differentials and mixer gears to provide PDU torque output; (2) four geared rotary actuators which apply the PDU generated torque to the rudder/speedbrake panels; and (3) ten torque shafts which join the PDU to the rotary actuators and interconnect the four rotary actuators. Each level of hardware was evaluated and analyzed for possible failures and causes. Criticality was assigned based upon the severity of the effect for each failure mode. Critical RSB failures which result in potential loss of vehicle control were mainly due to loss of hydraulic fluid, fluid contaminants, and mechanical failures in gears and shafts.

CASI

Brakes (For Arresting Motion); Directional Control; Failure Modes; Rudders; Space Shuttle Orbiters; Spacecraft Reliability; Speed Control

19900001601 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the data processing system FMEA/CIL

Lowery, H. J., McDonnell-Douglas Astronautics Co., USA; Haufler, W. A., McDonnell-Douglas Astronautics Co., USA; Nov 28, 1986; 305p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185546; NAS 1.26:185546; REPT-1.0-WP-VA86001-08; Avail: CASI; A14, Hardcopy; A03, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Data Processing System (DPS) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. The results of that comparison is documented for the Orbiter DPS hardware.

CASI

Computer Systems Design; Computer Systems Performance; Data Processing Equipment; Failure Modes; Space Shuttle Orbiters; Spacecraft Reliability

19900001602 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the electrical power generation/power reactant storage and distribution subsystem

Gotch, S. M., McDonnell-Douglas Astronautics Co., USA; Dec 5, 1986; 205p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185556; NAS 1.26:185556; REPT-1.0-WP-VA86001-11; Avail: CASI; A10, Hardcopy; A03, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NAA FMEA/CIL documentation. The independent analysis results corresponding to the Orbiter Electrical Power Generation (EPG)/Power Reactants Storage and Distribution (PRSD) System Hardware is documented. The EPG/PRSD hardware is required for performing critical functions of cryogenic hydrogen and oxygen storage and distribution to the Fuel Cell Powerplants (FCP) and Atmospheric Revitalization Pressure Control Subsystem (ARPCS). Specifically, the EPG/PRSD hardware consists of the following: Hydrogen (H₂) tanks; Oxygen (O₂) tanks; H₂ Relief Valve/Filter Packages (HRVFP); O₂ Relief Valve/Filter Packages (ORVFP); H₂ Valve Modules (HVM); O₂ Valve Modules (OVM); and O₂ and H₂ lines, components, and fittings.

CASI

Atmospheric Pressure; Controllers; Failure Modes; Fuel Cells; Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability

19900001603 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the orbital maneuvering system

Prust, C. D., McDonnell-Douglas Astronautics Co., USA; Paul, D. J., McDonnell-Douglas Astronautics Co., USA; Burkemper, V. J., McDonnell-Douglas Astronautics Co., USA; Jan 12, 1987; 1023p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185554; NAS 1.26:185554; REPT-1.0-WP-VA86001-21; Avail: CASI; A99, Hardcopy; A10, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The independent analysis results for the Orbital Maneuvering System (OMS) hardware are documented. The OMS provides the thrust to perform orbit insertion, orbit circularization, orbit transfer, rendezvous, and deorbit. The OMS is housed in two independent pods located one on each side of the tail and consists of the following subsystems: Helium Pressurization; Propellant Storage and Distribution; Orbital Maneuvering Engine; and Electrical Power Distribution and Control. The IOA analysis process utilized available OMS hardware drawings and schematics for defining hardware assemblies, components, and hardware items. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode.

CASI

Failure Modes; Orbital Maneuvering Vehicles; Pods (External Stores); Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability

19900001604 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the guidance, navigation, and control subsystem

Trahan, W. H., McDonnell-Douglas Astronautics Co., USA; Odonnell, R. A., McDonnell-Douglas Astronautics Co., USA; Pietz, K. C., McDonnell-Douglas Astronautics Co., USA; Hiott, J. M., McDonnell-Douglas Astronautics Co., USA; Dec 19, 1986; 179p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185555; NAS 1.26:185555; REPT-1.0-WP-VA86001-16; Avail: CASI; A09, Hardcopy; A02, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) is presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The independent analysis results corresponding to the Orbiter Guidance, Navigation, and Control (GNC) Subsystem hardware are documented. The function of the GNC hardware is to respond to guidance, navigation, and control software commands to effect vehicle control and to provide sensor and controller data to GNC

software. Some of the GNC hardware for which failure modes analysis was performed includes: hand controllers; Rudder Pedal Transducer Assembly (RPTA); Speed Brake Thrust Controller (SBTC); Inertial Measurement Unit (IMU); Star Tracker (ST); Crew Optical Alignment Site (COAS); Air Data Transducer Assembly (ADTA); Rate Gyro Assemblies; Accelerometer Assembly (AA); Aerosurface Servo Amplifier (ASA); and Ascent Thrust Vector Control (ATVC). The IOA analysis process utilized available GNC hardware drawings, workbooks, specifications, schematics, and systems briefs for defining hardware assemblies, components, and circuits. Each hardware item was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode.

CASI

Computer Programs; Directional Control; Failure Modes; Space Navigation; Space Shuttle Orbiters; Spacecraft Control; Spacecraft Guidance

19900001605 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the nose wheel steering subsystem

Mediavilla, Anthony Scott, McDonnell-Douglas Astronautics Co., USA; Nov 21, 1986; 117p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185548; NAS 1.26:185548; REPT-1.0-WP-VA86001-03; Avail: CASI; A06, Hardcopy; A02, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The independent analysis results for the Orbiter Nose Wheel Steering (NWS) hardware are documented. The NWS hardware provides primary directional control for the Orbiter vehicle during landing rollout. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. The original NWS design was envisioned as a backup system to differential braking for directional control of the Orbiter during landing rollout. No real effort was made to design the NWS system as fail operational. The brakes have much redundancy built into their design but the poor brake/tire performance has forced the NSTS to upgrade NWS to the primary mode of directional control during rollout. As a result, a large percentage of the NWS system components have become Potential Critical Items (PCI).

CASI

Braking; Failure Modes; Nose Wheels; Space Shuttle Orbiters; Spacecraft Landing; Spacecraft Reliability; Steering

19900001606 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): FMEA/CIL instructions and ground rules

Traves, S. T., McDonnell-Douglas Astronautics Co., USA; Oct 14, 1986; 73p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185551; NAS 1.26:185551; REPT-1.0-WP-VA86001-01; Avail: CASI; A04, Hardcopy; A01, Microfiche

The McDonnell Douglas Astronautics Company was selected to conduct an independent assessment of the Orbiter Failure Mode and Effects Analysis/Critical Items List (FMEA/CIL). Part of this effort involved an examination of the FMEA/CIL preparation instructions and ground rules. Assessment objectives were to identify omissions and ambiguities in the ground rules that may impede the identification of shuttle orbiter safety and mission critical items, and to ensure that ground rules allow these items to receive proper management visibility for risk assessment. Assessment objectives were followed during the performance of the assessment without being influenced by external considerations such as effects on budget, schedule, and documentation growth. Assessment personnel were employed who had a strong reliability background but no previous space shuttle FMEA/CIL experience to ensure an independent assessment would be achieved. The following observations were made: (1) not all essential items are in the CIL for management visibility; (2) ground rules omit FMEA/CIL coverage of items that perform critical functions; (3) essential items excluded from the CIL do not receive design justification; and (4) FMEAs/CILs are not updated in a timely manner. In addition to the above issues, a number of other issues were identified that correct FMEA/CIL preparation instruction omissions and clarify ambiguities. The assessment was successful in that many of the issues have significant safety implications.

CASI

Failure Modes; Space Shuttle Orbiters; Spacecraft Performance; Spacecraft Reliability

19900001607 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the electrical power generation/power reactant storage and distribution subsystem FMEA/CIL

Ames, B. E., McDonnell-Douglas Astronautics Co., USA; Feb 22, 1988; 239p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185545; NAS 1.26:185545; REPT-1.0-WP-VA88003-15; Avail: CASI; A11, Hardcopy; A03, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) is presented. The IOA effort first completed an analysis of the Electrical Power Generation/Power Reactant Storage and Distribution (EPG/PRSD) subsystem hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baselines with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. The results of that comparison are documented for the Orbiter EPG/PRSD hardware. The comparison produced agreement on all but 27 FMEAs and 9 CIL items. The discrepancy between the number of IOA findings and NASA FMEAs can be partially explained by the different approaches used by IOA and NASA to group failure modes together to form one FMEA. Also, several IOA items represented inner tank components and ground operations failure modes which were not in the NASA baseline.

CASI

Failure Modes; Ground Operational Support System; Propellant Tanks; Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability

19900001608 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the DPS subsystem

Lowery, H. J., McDonnell-Douglas Astronautics Co., USA; Hauffer, W. A., McDonnell-Douglas Astronautics Co., USA; Pietz, K. C., McDonnell-Douglas Astronautics Co., USA; Oct 24, 1986; 123p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185549; NAS 1.26:185549; REPT-1.0-WP-VA86001-02; Avail: CASI; A06, Hardcopy; A02, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis/Critical Items List (FMEA/CIL) is presented. The IOA approach features a top-down analysis of the hardware to independently determine failure modes, criticality, and potential critical items. The independent analysis results corresponding to the Orbiter Data Processing System (DPS) hardware are documented. The DPS hardware is required for performing critical functions of data acquisition, data manipulation, data display, and data transfer throughout the Orbiter. Specifically, the DPS hardware consists of the following components: Multiplexer/Demultiplexer (MDM); General Purpose Computer (GPC); Multifunction CRT Display System (MCDS); Data Buses and Data Bus Couplers (DBC); Data Bus Isolation Amplifiers (DBIA); Mass Memory Unit (MMU); and Engine Interface Unit (EIU). The IOA analysis process utilized available DPS hardware drawings and schematics for defining hardware assemblies, components, and hardware items. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. Due to the extensive redundancy built into the DPS the number of critical items are few. Those identified resulted from premature operation and erroneous output of the GPCs.

CASI

Data Acquisition; Data Processing Equipment; Failure Modes; Space Shuttle Orbiters; Spacecraft Reliability

19900001609 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the atmospheric revitalization pressure control subsystem

Saïidi, M. J., McDonnell-Douglas Astronautics Co., USA; Duffy, R. E., McDonnell-Douglas Astronautics Co., USA; McLaughlin, T. D., McDonnell-Douglas Astronautics Co., USA; Nov 28, 1986; 309p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185593; NAS 1.26:185593; REPT-1.0-WP-VA86001-12; Avail: CASI; A14, Hardcopy; A03, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis/Critical Items List (FMEA/CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The independent analysis results corresponding to the Orbiter Atmospheric Revitalization and Pressure Control Subsystem (ARPCS) are documented. The ARPCS hardware was categorized into the following subdivisions: (1) Atmospheric Make-up and Control (including the Auxiliary Oxygen Assembly, Oxygen Assembly, and Nitrogen Assembly); and (2) Atmospheric Vent and Control (including the Positive Relief Vent Assembly, Negative Relief Vent Assembly, and Cabin Vent Assembly). The IOA analysis process utilized available ARPCS hardware drawings and schematics for defining hardware assemblies, components, and hardware items. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode.

CASI

Failure Modes; Pressurized Cabins; Space Shuttle Orbiters; Spacecraft Cabin Atmospheres; Spacecraft Reliability

19900001610 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support, Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the remote manipulator system

Tangorra, F., McDonnell-Douglas Astronautics Co., USA; Grasmeyer, R. F., McDonnell-Douglas Astronautics Co., USA; Montgomery, A. D., McDonnell-Douglas Astronautics Co., USA; Jan 12, 1987; 618p; In English

Contract(s)/Grant(s): NAS9-17650

Report No(s): NASA-CR-185585; NAS 1.26:185585; REPT-1.0-WP-VA86001-23; Avail: CASI; A99, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items (PCIs). To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The independent analysis results for the Orbiter Remote Manipulator System (RMS) are documented. The RMS hardware and software are primarily required for deploying and/or retrieving up to five payloads during a single mission, capture and retrieve free-flying payloads, and for performing Manipulator Foot Restraint operations. Specifically, the RMS hardware consists of the following components: end effector; displays and controls; manipulator controller interface unit; arm based electronics; and the arm. The IOA analysis process utilized available RMS hardware drawings, schematics and documents for defining hardware assemblies, components and hardware items. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. Of the 574 failure modes analyzed, 413 were determined to be PCIs.

CASI

Computer Programs; Failure Modes; Payload Control; Remote Manipulator System; Space Shuttle Orbiters; Spacecraft Reliability

19900001611 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support, Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the orbiter main propulsion system

Mcnicoll, W. J., McDonnell-Douglas Astronautics Co., USA; Mcneely, M., McDonnell-Douglas Astronautics Co., USA; Holden, K. A., McDonnell-Douglas Astronautics Co., USA; Emmons, T. E., McDonnell-Douglas Astronautics Co., USA; Lowery, H. J., McDonnell-Douglas Astronautics Co., USA; Jan 16, 1987; 747p; In English

Contract(s)/Grant(s): NAS9-17650

Report No(s): NASA-CR-185584; NAS 1.26:185584; REPT-1.0-WP-VA86001-22; Avail: CASI; A99, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items (PCIs). To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The independent analysis results for the Orbiter Main Propulsion System (MPS) hardware are documented. The Orbiter MPS consists of two subsystems: the Propellant Management Subsystem (PMS) and the Helium Subsystem. The PMS is a system of manifolds, distribution lines and valves by which the liquid propellants pass from the External Tank (ET) to the Space Shuttle Main Engines (SSMEs) and gaseous propellants pass from the SSMEs to the ET. The Helium Subsystem consists of a series of helium supply tanks and their associated regulators, check valves,

distribution lines, and control valves. The Helium Subsystem supplies helium that is used within the SSMEs for inflight purges and provides pressure for actuation of SSME valves during emergency pneumatic shutdowns. The balance of the helium is used to provide pressure to operate the pneumatically actuated valves within the PMS. Each component was evaluated and analyzed for possible failure modes and effects. Criticalities were assigned based on the worst possible effect of each failure mode. of the 690 failure modes analyzed, 349 were determined to be PCIs.

CASI

External Tanks; Failure Modes; Propellant Transfer; Space Shuttle Main Engine; Space Shuttle Orbiters

19900001612 McDonnell-Douglas Corp., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the instrumentation subsystem

Howard, B. S., McDonnell-Douglas Corp., USA; Dec 12, 1986; 139p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185571; NAS 1.26:185571; REPT-1.0-WP-VA86001-17; Avail: CASI; A07, Hardcopy; A02, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The independent analysis results for the Instrumentation Subsystem are documented. The Instrumentation Subsystem (SS) consists of transducers, signal conditioning equipment, pulse code modulation (PCM) encoding equipment, tape recorders, frequency division multiplexers, and timing equipment. For this analysis, the SS is broken into two major groupings: Operational Instrumentation (OI) equipment and Modular Auxiliary Data System (MADS) equipment. The OI equipment is required to acquire, condition, scale, digitize, interleave/multiplex, format, and distribute operational Orbiter and payload data and voice for display, recording, telemetry, and checkout. It also must provide accurate timing for time critical functions for crew and payload specialist use. The MADS provides additional instrumentation to measure and record selected pressure, temperature, strain, vibration, and event data for post-flight playback and analysis. MADS data is used to assess vehicle responses to the flight environment and to permit correlation of such data from flight to flight. The IOA analysis utilized available SS hardware drawings and schematics for identifying hardware assemblies and components and their interfaces. Criticality for each item was assigned on the basis of the worst-case effect of the failure modes identified.

CASI

Failure Modes; Multiplexing; Postflight Analysis; Pulse Code Modulation; Space Shuttle Orbiters; Spacecraft Reliability

19900001613 McDonnell-Douglas Corp., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the ascent thrust vector control actuator subsystem

Wilson, R. E., McDonnell-Douglas Corp., USA; Riccio, J. R., McDonnell-Douglas Corp., USA; Nov 21, 1986; 59p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185579; NAS 1.26:185579; REPT-1.0-WP-VA86001-06; Avail: CASI; A04, Hardcopy; A01, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The independent analysis results for the Ascent Thrust Vector Control (ATVC) Actuator hardware are documented. The function of the Ascent Thrust Vector Control Actuators (ATVC) is to gimbal the main engines to provide for attitude and flight path control during ascent. During first stage flight, the SRB nozzles provide nearly all the steering. After SRB separation, the Orbiter is steered by gimbaling of its main engines. There are six electrohydraulic servoactuators, one pitch and one yaw for each of the three main engines. Each servoactuator is composed of four electrohydraulic servovalve assemblies, one second stage power spool valve assembly, one primary piston assembly and a switching valve. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. Critical failures resulting in loss of ATVC were mainly due to loss of hydraulic fluid, fluid contamination and mechanical failures.

CASI

Attitude Control; Control Systems Design; Directional Control; Failure Modes; Space Shuttle Orbiters; Spacecraft Reliability; Thrust Vector Control

19900001614 McDonnell-Douglas Corp., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the body flap subsystem

Wilson, R. E., McDonnell-Douglas Corp., USA; Riccio, J. R., McDonnell-Douglas Corp., USA; Nov 21, 1986; 68p; In English
Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185574; NAS 1.26:185574; REPT-1.0-WP-VA86001-05; Avail: CASI; A04, Hardcopy; A01, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items (PCIs). To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The independent analysis results for the Orbiter Body Flap (BF) subsystem hardware are documented. The BF is a large aerosurface located at the trailing edge of the lower aft fuselage of the Orbiter. The proper function of the BF is essential during the dynamic flight phases of ascent and entry. During the ascent phase of flight, the BF trails in a fixed position. For entry, the BF provides elevon load relief, trim control, and acts as a heat shield for the main engines. Specifically, the BF hardware comprises the following components: Power Drive Unit (PDU), rotary actuators, and torque tubes. The IOA analysis process utilized available BF hardware drawings and schematics for defining hardware assemblies, components, and hardware items. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. Of the 35 failure modes analyzed, 19 were determined to be PCIs.

CASI

Failure Modes; Flaps (Control Surfaces); Flight Control; Space Shuttle Orbiters; Spacecraft Reliability

19900001615 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the auxiliary power unit

Barnes, J. E., McDonnell-Douglas Astronautics Co., USA; Dec 12, 1986; 388p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185568; NAS 1.26:185568; REPT-1.0-WP-VA86001-14; Avail: CASI; A17, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Orbiter Auxiliary Power Unit (APU). The APUs are required to provide power to the Orbiter hydraulics systems during ascent and entry flight phases for aerosurface actuation, main engine gimballing, landing gear extension, and other vital functions. For analysis purposes, the APU system was broken down into ten functional subsystems. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. A preponderance of 1/1 criticality items were related to failures that allowed the hydrazine fuel to escape into the Orbiter aft compartment, creating a severe fire hazard, and failures that caused loss of the gas generator injector cooling system.

CASI

Auxiliary Power Sources; Failure Modes; Space Shuttle Orbiters; Spacecraft Reliability

19900001616 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the backup flight system

Prust, E. E., McDonnell-Douglas Astronautics Co., USA; Mielke, R. W., McDonnell-Douglas Astronautics Co., USA; Hinsdale, L. W., McDonnell-Douglas Astronautics Co., USA; Dec 8, 1986; 63p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185567; NAS 1.26:185567; REPT-1.0-WP-VA86001-18; Avail: CASI; A04, Hardcopy; A01, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the analysis results corresponding to the Orbiter Backup Flight System (BFS) hardware. The BFS hardware consists of one General Purpose Computer (GPC) loaded with backup

flight software and the components used to engage/disengage that unique GPC. Specifically, the BFS hardware includes the following: DDU (Display Driver Unit), BFC (Backup Flight Controller), GPC (General Purpose Computer), switches (engage, disengage, GPC, CRT), and circuit protectors (fuses, circuit breakers). The IOA analysis process utilized available BFS hardware drawings and schematics for defining hardware assemblies, components, and hardware items. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. of the failure modes analyzed, 19 could potentially result in a loss of life and/or loss of vehicle.

CASI

Airborne/Spaceborne Computers; Applications Programs (Computers); Circuit Breakers; Circuits; Display Devices; Failure Modes; Flight Control; Protectors; Space Shuttle Orbiters; Spacecraft Control; Spacecraft Reliability; Switches

19900001617 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the electrical power distribution and control/electrical power generation subsystem

Patton, Jeff A., McDonnell-Douglas Astronautics Co., USA; Dec 19, 1986; 303p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185538; NAS 1.26:185538; REPT-1.0-WP-VA86001-19; Avail: CASI; A14, Hardcopy; A03, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Orbiter Electrical Power Distribution and Control (EPD and C)/Electrical Power Generation (EPG) hardware. The EPD and C/EPG hardware is required for performing critical functions of cryogenic reactant storage, electrical power generation and product water distribution in the Orbiter. Specifically, the EPD and C/EPG hardware consists of the following components: Power Section Assembly (PSA); Reactant Control Subsystem (RCS); Thermal Control Subsystem (TCS); Water Removal Subsystem (WRS); and Power Reactant Storage and Distribution System (PRSDS). The IOA analysis process utilized available EPD and C/EPG hardware drawings and schematics for defining hardware assemblies, components, and hardware items. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode.

CASI

Control Systems Design; Controllers; Cryogenic Fluid Storage; Electric Power Transmission; Failure Modes; Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability; Spacecraft Temperature; Temperature Control; Water

19900001618 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the hydraulics/water spray boiler subsystem

Duval, J. D., McDonnell-Douglas Astronautics Co., USA; Davidson, W. R., McDonnell-Douglas Astronautics Co., USA; Parkman, William E., McDonnell-Douglas Astronautics Co., USA; Dec 19, 1986; 486p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185541; NAS 1.26:185541; REPT-1.0-WP-VA86001-20; Avail: CASI; A21, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items (PCIs). to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results for the Orbiter Hydraulics/Water Spray Boiler Subsystem. The hydraulic system provides hydraulic power to gimbal the main engines, actuate the main engine propellant control valves, move the aerodynamic flight control surfaces, lower the landing gear, apply wheel brakes, steer the nosewheel, and dampen the external tank (ET) separation. Each hydraulic system has an associated water spray boiler which is used to cool the hydraulic fluid and APU lubricating oil. The IOA analysis process utilized available HYD/WSB hardware drawings, schematics and documents for defining hardware assemblies, components, and hardware items. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. of the 430 failure modes analyzed, 166 were determined to be PCIs.

CASI

Boilers; Control Valves; Engine Control; Failure Modes; Flight Control; Hydraulic Equipment; Space Shuttle Orbiters; Spacecraft Reliability; Sprayers; Water

19900001619 McDonnell-Douglas Corp., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the elevon subsystem

Wilson, R. E., McDonnell-Douglas Corp., USA; Riccio, J. R., McDonnell-Douglas Corp., USA; Nov 21, 1986; 56p; In English
Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185576; NAS 1.26:185576; REPT-1.0-WP-VA86001-07; Avail: CASI; A04, Hardcopy; A01, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results for the Orbiter Elevon system hardware. The elevon actuators are located at the trailing edge of the wing surface. The proper function of the elevons is essential during the dynamic flight phases of ascent and entry. In the ascent phase of flight, the elevons are used for relieving high wing loads. For entry, the elevons are used to pitch and roll the vehicle. Specifically, the elevon system hardware comprises the following components: flow cutoff valve; switching valve; electro-hydraulic (EH) servoactuator; secondary delta pressure transducer; bypass valve; power valve; power valve check valve; primary actuator; primary delta pressure transducer; and primary actuator position transducer. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. Of the 25 failure modes analyzed, 18 were determined to be PCIs.

CASI

Actuators; Elevons; Failure Modes; Hydraulic Equipment; Space Shuttle Orbiters; Spacecraft Reliability; Wings

19900001620 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the electrical power distribution and control/remote manipulator system subsystem

Robinson, W. W., McDonnell-Douglas Astronautics Co., USA; Feb 17, 1987; 384p; In English
Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185526; NAS 1.26:185526; REPT-1.0-WP-VA86001-26; Avail: CASI; A17, Hardcopy; A03, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the Electrical Power Distribution and Control (EPD and C)/Remote Manipulator System (RMS) hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained in the NASA FMEA/CIL documentation. This report documents the results of the independent analysis of the EPD and C/RMS (both port and starboard) hardware. The EPD and C/RMS subsystem hardware provides the electrical power and power control circuitry required to safely deploy, operate, control, and stow or guillotine and jettison two (one port and one starboard) RMSs. The EPD and C/RMS subsystem is subdivided into the four following functional divisions: Remote Manipulator Arm; Manipulator Deploy Control; Manipulator Latch Control; Manipulator Arm Shoulder Jettison; and Retention Arm Jettison. The IOA analysis process utilized available EPD and C/RMS hardware drawings and schematics for defining hardware assemblies, components, and hardware items. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based on the severity of the effect for each failure mode.

CASI

Controllers; Electric Power Transmission; Failure Modes; Jettisoning; Latches; Remote Manipulator System; Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability

19900001621 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the extravehicular mobility unit

Raffaelli, Gary G., McDonnell-Douglas Astronautics Co., USA; Dec 15, 1986; 558p; In English
Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185540; NAS 1.26:185540; REPT-1.0-WP-VA86001-15; Avail: CASI; A24, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes,

criticality, and potential critical items (PCIs). to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Extravehicular Mobility Unit (EMU) hardware. The EMU is an independent anthropomorphic system that provides environmental protection, mobility, life support, and communications for the Shuttle crewmember to perform Extravehicular Activity (EVA) in Earth orbit. Two EMUs are included on each baseline Orbiter mission, and consumables are provided for three two-man EVAs. The EMU consists of the Life Support System (LSS), Caution and Warning System (CWS), and the Space Suit Assembly (SSA). Each level of hardware was evaluated and analyzed for possible failure modes and effects. The majority of these PCIs are resultant from failures which cause loss of one or more primary functions: pressurization, oxygen delivery, environmental maintenance, and thermal maintenance. It should also be noted that the quantity of PCIs would significantly increase if the SOP were to be treated as an emergency system rather than as an unlike redundant element.

CASI

Extravehicular Activity; Extravehicular Mobility Units; Failure Modes; Life Support Systems; Space Shuttle Orbiters; Space Suits; Spacecraft Reliability; Spacecrews; Warning Systems

19900001622 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the reaction control system, volume 1

Burkemper, V. J., McDonnell-Douglas Astronautics Co., USA; Haufler, W. A., McDonnell-Douglas Astronautics Co., USA; Odonnell, R. A., McDonnell-Douglas Astronautics Co., USA; Paul, D. J., McDonnell-Douglas Astronautics Co., USA; Jan 19, 1987; 790p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185532-VOL-1; NAS 1.26:185532-VOL-1; REPT-1.0-WP-VA86001-27-VOL-1; Avail: CASI; A99, Hardcopy; A10, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results for the Reaction Control System (RCS). The purpose of the RCS is to provide thrust in and about the X, Y, Z axes for External Tank (ET) separation; orbit insertion maneuvers; orbit translation maneuvers; on-orbit attitude control; rendezvous; proximity operations (payload deploy and capture); deorbit maneuvers; and abort attitude control. The RCS is situated in three independent modules, one forward in the orbiter nose and one in each OMS/RCS pod. Each RCS module consists of the following subsystems: Helium Pressurization Subsystem; Propellant Storage and Distribution Subsystem; Thruster Subsystem; and Electrical Power Distribution and Control Subsystem. Of the failure modes analyzed, 307 could potentially result in a loss of life and/or loss of vehicle.

CASI

Attitude Control; Control Systems Design; Controllers; Failure Modes; Space Shuttle Orbiters; Spacecraft Maneuvers; Spacecraft Reliability

19900001623 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the reaction control system, volume 2

Burkemper, V. J., McDonnell-Douglas Astronautics Co., USA; Haufler, W. A., McDonnell-Douglas Astronautics Co., USA; Odonnell, R. A., McDonnell-Douglas Astronautics Co., USA; Paul, D. J., McDonnell-Douglas Astronautics Co., USA; Jan 19, 1987; 797p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185532-VOL-2; NAS 1.26:185532-VOL-2; REPT-1.0-WP-VA86001-27-VOL-2; Avail: CASI; A99, Hardcopy; A10, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results for the Reaction Control System (RCS). The RCS is situated in three independent modules, one forward in the orbiter nose and one in each OMS/RCS pod. Each RCS module consists of the following subsystems: Helium Pressurization Subsystem; Propellant Storage

and Distribution Subsystem; Thruster Subsystem; and Electrical Power Distribution and Control Subsystem. Volume 2 continues the presentation of IOA analysis worksheets.

CASI

Control Systems Design; Controllers; Electric Power Transmission; Failure Modes; Pressurizing; Propellant Storage; Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability

19900001624 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the reaction control system, volume 3

Burkemper, V. J., McDonnell-Douglas Astronautics Co., USA; Haufler, W. A., McDonnell-Douglas Astronautics Co., USA; Odonnell, R. A., McDonnell-Douglas Astronautics Co., USA; Paul, D. J., McDonnell-Douglas Astronautics Co., USA; Jan 19, 1987; 767p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185532-VOL-3; NAS 1.26:185532-VOL-3; REPT-1.0-WP-VA86001-27-VOL-3; Avail: CASI; A99, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results for the Reaction Control System (RCS). The RCS is situated in three independent modules, one forward in the orbiter nose and one in each OMS/RCS pod. Each RCS module consists of the following subsystems: Helium Pressurization Subsystem; Propellant Storage and Distribution Subsystem; Thruster Subsystem; and Electrical Power Distribution and Control Subsystem. Volume 3 continues the presentation of IOA analysis worksheets and the potential critical items list.

CASI

Control Systems Design; Controllers; Electric Power Transmission; Failure Modes; Pods (External Stores); Pressurizing; Propellant Storage; Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability

19900001625 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the electrical power distribution and control subsystem, volume 1

Schmeckpeper, K. R., McDonnell-Douglas Astronautics Co., USA; Apr 3, 1987; 832p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185529-VOL-1; NAS 1.26:185529-VOL-1; REPT-1.0-WP-VA86001-28-VOL-1; Avail: CASI; A99, Hardcopy; A10, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Orbiter Electrical Power Distribution and Control (EPD and C) hardware. The EPD and C hardware performs the functions of distributing, sensing, and controlling 28 volt DC power and of inverting, distributing, sensing, and controlling 117 volt 400 Hz AC power to all Orbiter subsystems from the three fuel cells in the Electrical Power Generation (EPG) subsystem. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. of the 1671 failure modes analyzed, 9 single failures were determined to result in loss of crew or vehicle. Three single failures unique to intact abort were determined to result in possible loss of the crew or vehicle. A possible loss of mission could result if any of 136 single failures occurred. Six of the criticality 1/1 failures are in two rotary and two pushbutton switches that control External Tank and Solid Rocket Booster separation. The other 6 criticality 1/1 failures are fuses, one each per Aft Power Control Assembly (APCA) 4, 5, and 6 and one each per Forward Power Control Assembly (FPCA) 1, 2, and 3, that supply power to certain Main Propulsion System (MPS) valves and Forward Reaction Control System (RCS) circuits.

CASI

Control Systems Design; Controllers; Electric Power Transmission; Failure Modes; Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability; Stage Separation

19900001626 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support, Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the electrical power distribution and control subsystem, volume 2
Schmeckpeper, K. R., McDonnell-Douglas Astronautics Co., USA; Apr 3, 1987; 884p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185529-VOL-2; NAS 1.26:185529-VOL-2; REPT-1.0-WP-VA86001-28-VOL-2; Avail: CASI; A99, Hardcopy; A10, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Orbiter Electrical Power Distribution and Control (EPD and C) hardware. The EPD and C hardware performs the functions of distributing, sensing, and controlling 28 volt DC power and of inverting, distributing, sensing, and controlling 117 volt 400 Hz AC power to all Orbiter subsystems from the three fuel cells in the Electrical Power Generation (EPG) subsystem. Volume 2 continues the presentation of IOA analysis worksheets and contains the potential critical items list.

CASI

Control Systems Design; Controllers; Electric Power Transmission; Failure Modes; Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability

19900001627 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support, Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the landing/deceleration subsystem

Compton, J. M., McDonnell-Douglas Astronautics Co., USA; Beaird, H. G., McDonnell-Douglas Astronautics Co., USA; Weissinger, W. D., McDonnell-Douglas Astronautics Co., USA; Jan 19, 1987; 298p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185569; NAS 1.26:185569; REPT-1.0-WP-VA86001-25; Avail: CASI; A13, Hardcopy; A03, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Orbiter Landing/Deceleration Subsystem hardware. The Landing/Deceleration Subsystem is utilized to allow the Orbiter to perform a safe landing, allowing for landing-gear deploy activities, steering and braking control throughout the landing rollout to wheel-stop, and to allow for ground-handling capability during the ground-processing phase of the flight cycle. Specifically, the Landing/Deceleration hardware consists of the following components: Nose Landing Gear (NLG); Main Landing Gear (MLG); Brake and Antiskid (B and AS) Electrical Power Distribution and Controls (EPD and C); Nose Wheel Steering (NWS); and Hydraulics Actuators. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. Due to the lack of redundancy in the Landing/Deceleration Subsystems there is a high number of critical items.

CASI

Braking; Failure Modes; Hydraulic Equipment; Landing Gear; Nose Wheels; Space Shuttle Orbiters; Spacecraft Reliability; Steering

19900001628 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the mechanical actuation subsystem

Bacher, J. L., McDonnell-Douglas Astronautics Co., USA; Montgomery, A. D., McDonnell-Douglas Astronautics Co., USA; Bradway, M. W., McDonnell-Douglas Astronautics Co., USA; Slaughter, W. T., McDonnell-Douglas Astronautics Co., USA; Nov 30, 1987; 770p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185525; REPT-1.0-WP-VA87001-03; NAS 1.26:185525; Avail: CASI; A99, Hardcopy; A10, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results

contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Orbiter Mechanical Actuation System (MAS) hardware. Specifically, the MAS hardware consists of the following components: Air Data Probe (ADP); Elevon Seal Panel (ESP); External Tank Umbilical (ETU); Ku-Band Deploy (KBD); Payload Bay Doors (PBD); Payload Bay Radiators (PBR); Personnel Hatches (PH); Vent Door Mechanism (VDM); and Startracker Door Mechanism (SDM). The IOA analysis process utilized available MAS hardware drawings and schematics for defining hardware assemblies, components, and hardware items. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode.

CASI

Actuators; Doors; Elevons; Failure Modes; Hatches; Space Shuttle Orbiters; Spacecraft Reliability

19900001629 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the pyrotechnics subsystem

Robinson, W. W., McDonnell-Douglas Astronautics Co., USA; Jan 1, 1988; 82p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185530; NAS 1.26:185530; REPT-1.0-WP-VA88005-01; Avail: CASI; A05, Hardcopy; A01, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Orbiter Pyrotechnics hardware. The IOA analysis process utilized available pyrotechnics hardware drawings and schematics for defining hardware assemblies, components, and hardware items. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode.

CASI

Failure Modes; Pyrotechnics; Space Shuttle Orbiters; Spacecraft Reliability

19900001630 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the pyrotechnics subsystem

Robinson, W. M., McDonnell-Douglas Astronautics Co., USA; Feb 5, 1988; 90p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185531; NAS 1.26:185531; REPT-1.0-WP-VA88005-05; Avail: CASI; A05, Hardcopy; A01, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Pyrotechnics (PYRO) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter Pyrotechnics hardware.

CASI

Failure Modes; Pyrotechnics; Space Shuttle Orbiters; Spacecraft Reliability

19900001631 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the nose wheel steering subsystem

Mediavilla, Anthony Scott, McDonnell-Douglas Astronautics Co., USA; Mar 11, 1988; 139p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185533; NAS 1.26:185533; REPT-1.0-WP-VA88003-22; Avail: CASI; A07, Hardcopy; A02, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Nose Wheel Steering (NWS) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the

proposed NASA post 51-L FMEA/CIL baseline. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter NWS hardware.

CASI

Failure Modes; Nose Wheels; Space Shuttle Orbiters; Spacecraft Reliability; Steering

19900001633 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the purge, vent and drain subsystem

Bynum, M. C., III, McDonnell-Douglas Astronautics Co., USA; Feb 5, 1988; 109p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185535; NAS 1.26:185535; REPT-1.0-WP-VA88005-02; Avail: CASI; A06, Hardcopy; A02, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Purge, Vent and Drain (PV and D) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter PV and D hardware. The PV and D Subsystem controls the environment of unpressurized compartments and window cavities, senses hazardous gases, and purges Orbiter/ET disconnect.

CASI

Drainage; Failure Modes; Gas Detectors; Space Shuttle Orbiters; Spacecraft Reliability; Vents

19900001634 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the extravehicular mobility unit, volume 1

Raffaelli, Gary G., McDonnell-Douglas Astronautics Co., USA; Mar 10, 1988; 546p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185536-VOL-1; NAS 1.26:185536-VOL-1; REPT-1.0-WP-VA88003-41-VOL-1; Avail: CASI; A23, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort performed an independent analysis of the Extravehicular Mobility Unit (EMU) hardware and system, generating draft failure modes criticalities and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the most recent proposed Post 51-L NASA FMEA/CIL baseline. A resolution of each discrepancy from the comparison was provided through additional analysis as required. This report documents the results of that comparison for the Orbiter EMU hardware.

CASI

Extravehicular Mobility Units; Failure Modes; Space Shuttle Orbiters; Spacecraft Reliability

19900001635 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the extravehicular mobility unit, volume 2

Raffaelli, Gary G., McDonnell-Douglas Astronautics Co., USA; Mar 10, 1988; 403p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185536-VOL-2; NAS 1.26:185536-VOL-2; REPT-1.0-WP-VA88003-41-VOL-2; Avail: CASI; A18, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort performed an independent analysis of the Extravehicular Mobility Unit (EMU) hardware and system, generating draft failure modes criticalities and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the most recent proposed Post 51-L NASA FMEA/CIL baseline. A resolution of each discrepancy from the comparison was provided through additional analysis as required. This report documents the results of that comparison for the Orbiter EMU hardware. Volume 2 continues the presentation of IOA analysis worksheets and contains the potential critical items list and NASA FMEA to IOA worksheet cross references and recommendations.

CASI

Extravehicular Mobility Units; Failure Modes; Space Shuttle Orbiters; Spacecraft Reliability

19900001636 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the mechanical actuation subsystem, volume 1

Bradway, M. W., McDonnell-Douglas Astronautics Co., USA; Slaughter, W. T., McDonnell-Douglas Astronautics Co., USA; Mar 7, 1988; 562p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185527-VOL-1; NAS 1.26:185527-VOL-1; REPT-1.0-WP-VA88003-09-VOL-1; Avail: CASI; A24, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine draft failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the proposed Post 51-L NASA FMEA/CIL baseline that was available. A resolution of each discrepancy from the comparison was provided through additional analysis as required. These discrepancies were flagged as issues, and recommendations were made based on the FMEA data available at the time. This report documents the results of that comparison for the Orbiter Mechanical Actuation System (MAS) hardware. Specifically, the MAS hardware consists of the following components: Air Data Probe (ADP); Elevon Seal Panel (ESP); External Tank Umbilical (ETU); Ku-Band Deploy (KBD); Payload Bay Doors (PBD); Payload Bay Radiators (PBR); Personnel Hatches (PH); Vent Door Mechanism (VDM); and Startracker Door Mechanism (SDM). Criticality was assigned based upon the severity of the effect for each failure mode.

CASI

Actuators; Bays (Structural Units); Doors; Elevons; External Tanks; Failure Modes; Hatches; Seals (Stoppers); Space Shuttle Orbiters; Spacecraft Reliability; Umbilical Connectors; Vents

19900001637 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the mechanical actuation subsystem, volume 2

Bradway, M. W., McDonnell-Douglas Astronautics Co., USA; Slaughter, W. T., McDonnell-Douglas Astronautics Co., USA; Mar 7, 1988; 562p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185527-VOL-2; NAS 1.26:185527-VOL-2; REPT-1.0-WP-VA88003-09-VOL-2; Avail: CASI; A24, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine draft failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the proposed Post 51-L NASA FMEA/CIL baseline that was available. A resolution of each discrepancy from the comparison was provided through additional analysis as required. These discrepancies were flagged as issues, and recommendations were made based on the FMEA data available at the time. This report documents the results of that comparison for the Orbiter Mechanical Actuation System (MAS) hardware. Specifically, the MAS hardware consists of the following components: Air Data Probe (ADP); Elevon Seal Panel (ESP); External Tank Umbilical (ETU); Ku-Band Deploy (KBD); Payload Bay Doors (PBD); Payload Bay Radiators (PBR); Personnel Hatches (PH); Vent Door Mechanism (VDM); and Startracker Door Mechanism (SDM). Criticality was assigned based upon the severity of the effect for each failure mode. Volume 2 continues the presentation of IOA analysis worksheets and contains the potential critical items list, detailed analysis, and NASA FMEA/CIL to IOA worksheet cross reference and recommendations.

CASI

Actuators; Bays (Structural Units); Doors; Elevons; External Tanks; Failure Modes; Hatches; Seals (Stoppers); Space Shuttle Orbiters; Spacecraft Reliability; Vents

19900001638 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): CIL issues resolution report, volume 1

Urbanowicz, Kenneth J., McDonnell-Douglas Astronautics Co., USA; Hinsdale, L. W., McDonnell-Douglas Astronautics Co., USA; Barnes, J. E., McDonnell-Douglas Astronautics Co., USA; Sep 16, 1988; 949p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185524-VOL-1; NAS 1.26:185524-VOL-1; REPT-1.0-WP-VA88003-48-VOL-1; Avail: CASI; A99, Hardcopy; A10, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. This report contains IOA assessment worksheets showing resolution of outstanding IOA CIL issues that were summarized in the IOA FMEA/CIL Assessment Interim Report, dated 9 March 1988. Each assessment worksheet has been updated with CIL issue resolution and rationale. The NASA and Prime Contractor post 51-L FMEA/CIL documentation assessed is believed to be technically accurate and complete. No assessment issues remain that has safety implications. Volume 1 contain worksheets for the following subsystems: Landing and Deceleration Subsystem; Purge, Vent and Drain Subsystem; Active Thermal Control and Life Support Systems; Crew Equipment Subsystem; Instrumentation Subsystem; Data Processing Subsystem; Atmospheric Revitalization Pressure Control Subsystem; Hydraulics and Water Spray Boiler Subsystem; and Mechanical Actuation Subsystem.

CASI

Active Control; Control Systems Design; Data Processing Equipment; Failure Modes; Life Support Systems; Space Shuttle Orbiters; Temperature Control

19900001639 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): CIL issues resolution report, volume 2

Sep 16, 1988; 924p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185524-VOL-2; NAS 1.26:185524-VOL-2; Avail: CASI; A99, Hardcopy; A10, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. This report contains IOA assessment worksheets showing resolution of outstanding IOA CIL issues that were summarized in the IOA FMEA/CIL Assessment Interim Report, dated 9 March 1988. Each assessment worksheet has been updated with CIL issue resolution and rationale. Volume 2 contains the worksheets for the following subsystems: Nose Wheel Steering Subsystem; Remote Manipulator Subsystem; Atmospheric Revitalization Subsystem; Extravehicular Mobility Unit Subsystem; Power Reactant Supply and Distribution Subsystem; Main Propulsion Subsystem; and Orbital Maneuvering Subsystem.

CASI

Air Purification; Extravehicular Mobility Units; Failure Modes; Nose Wheels; Remote Manipulator System; Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability; Steering

19900001640 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA) CIL issues resolution report, volume 3

Sep 16, 1988; 928p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185524-VOL-3; NAS 1.26:185524-VOL-3; Avail: CASI; A99, Hardcopy; A10, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. This report contains IOA assessment worksheets showing resolution of outstanding IOA CIL issues that were summarized in the IOA FMEA/CIL Assessment Interim Report, dated 9 March 1988. Each assessment worksheet has been updated with CIL issue resolution and rationale. Volume 3 contains the worksheets for the Reaction Control Subsystem and the Communications and Tracking Subsystem.

CASI

Communication Equipment; Component Reliability; Control Systems Design; Failure Modes; Space Shuttle Orbiters; Spacecraft Propulsion; Spacecraft Reliability; Spacecraft Tracking

19900001641 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the atmospheric revitalization pressure control subsystem FMEA/CIL

Saiedi, M. J., McDonnell-Douglas Astronautics Co., USA; Feb 19, 1988; 374p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185594; NAS 1.26:185594; REPT-1.0-WP-VA88003-09; Avail: CASI; A16, Hardcopy; A03, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the atmospheric Revitalization Pressure Control Subsystem (ARPCS) hardware, generating draft failure modes and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL proposed Post 51-L updates based upon the CCB/PRCB presentations and an informal criticality summary listing. A discussion of each discrepancy from the comparison is provided through additional analysis as required. These discrepancies were flagged as issues, and recommendations were made based on the FMEA data available at the time. This report documents the results of that comparison for the Orbiter ARPCS hardware.

CASI

Atmospheric Pressure; Control Systems Design; Failure Modes; Life Support Systems; Pressurized Cabins; Space Shuttle Orbiters; Spacecraft Reliability

19900001642 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the crew equipment subsystem

Sinclair, Susan, McDonnell-Douglas Astronautics Co., USA; Graham, L., McDonnell-Douglas Astronautics Co., USA; Richard, Bill, McDonnell-Douglas Astronautics Co., USA; Saxon, H., McDonnell-Douglas Astronautics Co., USA; Nov 2, 1987; 435p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185591; NAS 1.26:185591; REPT-1.0-WP-VA87001-01; Avail: CASI; A19, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical (PCIs) items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The independent analysis results corresponding to the Orbiter crew equipment hardware are documented. The IOA analysis process utilized available crew equipment hardware drawings and schematics for defining hardware assemblies, components, and hardware items. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. of the 352 failure modes analyzed, 78 were determined to be PCIs.

CASI

Extravehicular Activity; Failure Modes; Space Shuttle Orbiters; Space Suits; Spacecraft Reliability; Spacecrews

19900001643 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the ascent thrust vector control actuator subsystem FMEA/CIL
Wilson, R. E., McDonnell-Douglas Astronautics Co., USA; Feb 5, 1988; 67p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185590; NAS 1.26:185590; REPT-1.0-WP-VA88003-03; Avail: CASI; A04, Hardcopy; A01, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Ascent Thrust Vector Control Actuator (ATVC) hardware, generating draft failure modes and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter ATVC hardware. The IOA product for the ATVC actuator analysis consisted of 25 failure mode worksheets that resulted in 16 potential critical items being identified. Comparison was made to the NASA baseline which consisted of 21 FMEAs and 13 CIL items. This comparison produced agreement on all CIL items. Based on the Pre 51-L baseline, all non-CIL FMEAs were also in agreement.

CASI

Actuators; Control Systems Design; Failure Modes; Flight Control; Space Shuttle Orbiters; Spacecraft Reliability; Thrust Vector Control

19900001644 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): FMEA/CIL assessment *Final Report*

Hinsdale, L. W., McDonnell-Douglas Astronautics Co., USA; Swain, L. J., McDonnell-Douglas Astronautics Co., USA; Barnes, J. E., McDonnell-Douglas Astronautics Co., USA; Sep 16, 1988; 104p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185589; NAS 1.26:185589; REPT-1.0-WP-VA88003-47; Avail: CASI; A06, Hardcopy; A02, Microfiche

The McDonnell Douglas Astronautics Company (MDAC) was selected to perform an Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL). Direction was given by the Orbiter and GFE Projects Office to perform the hardware analysis and assessment using the instructions and ground rules defined in NSTS 22206. The IOA analysis featured a top-down approach to determine hardware failure modes, criticality, and potential critical items. To preserve independence, the analysis was accomplished without reliance upon the results contained within the NASA and Prime Contractor FMEA/CIL documentation. The assessment process compared the independently derived failure modes and criticality assignments to the proposed NASA Post 51-L FMEA/CIL documentation. When possible, assessment issues were discussed and resolved with the NASA subsystem managers. Unresolved issues were elevated to the Orbiter and GFE Projects Office manager, Configuration Control Board (CCB), or Program Requirements Control Board (PRCB) for further resolution. The most important Orbiter assessment finding was the previously unknown stuck autopilot push-button criticality 1/1 failure mode. The worst case effect could cause loss of crew/vehicle when the microwave landing system is not active. It is concluded that NASA and Prime Contractor Post 51-L FMEA/CIL documentation assessed by IOA is believed to be technically accurate and complete. All CIL issues were resolved. No FMEA issues remain that have safety implications. Consideration should be given, however, to upgrading NSTS 22206 with definitive ground rules which more clearly spell out the limits of redundancy. CASI

Component Reliability; Configuration Management; Failure Modes; Space Shuttle Orbiters; Spacecraft Components; Spacecraft Reliability; System Failures; Systems Engineering

19900001645 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the displays and controls subsystem

Trahan, W. H., McDonnell-Douglas Astronautics Co., USA; Prust, E. E., McDonnell-Douglas Astronautics Co., USA; Dec 26, 1987; 397p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185588; NAS 1.26:185588; REPT-1.0-WP-VA88005-04; Avail: CASI; A17, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Displays and Control hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy is provided through additional analysis as required. The results of that comparison for the Orbiter D and C hardware are documented. CASI

CASI

Control Systems Design; Display Devices; Failure Modes; Space Shuttle Orbiters; Spacecraft Reliability; Warning Systems

19900001646 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the Orbiter Experiment (OEX) subsystem

Compton, J. M., McDonnell-Douglas Astronautics Co., USA; Feb 5, 1988; 127p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185587; NAS 1.26:185587; REPT-1.0-WP-VA88005-03; Avail: CASI; A07, Hardcopy; A02, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Orbiter Experiments (OEX) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL

baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. The results of that comparison for the Orbiter OEX hardware are documented. The IOA product for the OEX analysis consisted of 82 failure mode worksheets that resulted in two potential critical items being identified.

CASI

Aerodynamic Coefficients; Air Data Systems; Failure Modes; In-Flight Monitoring; Space Shuttle Orbiters; Spacecraft Instruments; Spacecraft Reliability; Temperature Sensors

19900001647 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the Orbiter Experiment (OEX) subsystem

Compton, J. M., McDonnell-Douglas Astronautics Co., USA; Aug 21, 1987; 119p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185586; NAS 1.26:185586; REPT-1.0-WP-VA87001-07; Avail: CASI; A06, Hardcopy; A02, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Orbiter Experiments hardware. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. The Orbiter Experiments (OEX) Program consists of a multiple set of experiments for the purpose of gathering environmental and aerodynamic data to develop more accurate ground models for Shuttle performance and to facilitate the design of future spacecraft. This assessment only addresses currently manifested experiments and their support systems. Specifically this list consists of: Shuttle Entry Air Data System (SEADS); Shuttle Upper Atmosphere Mass Spectrometer (SUMS); Forward Fuselage Support System for OEX (FFSSO); Shuttle Infrared Laced Temperature Sensor (SILTS); Aerodynamic Coefficient Identification Package (ACIP); and Support System for OEX (SSO). There are only two potential critical items for the OEX, since the experiments only gather data for analysis post mission and are totally independent systems except for power. Failure of any experiment component usually only causes a loss of experiment data and in no way jeopardizes the crew or mission.

CASI

Aerodynamic Coefficients; Air Data Systems; Assessments; Failure Modes; In-Flight Monitoring; Space Shuttle Orbiters; Spacecraft Instruments; Spacecraft Reliability

19900001648 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the remote manipulator system FMEA/CIL

Tangorra, F., McDonnell-Douglas Astronautics Co., USA; Grasmeder, R. F., McDonnell-Douglas Astronautics Co., USA; Montgomery, A. D., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 968p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185592; NAS 1.26:185592; REPT-1.0-WP-VA88003-16; Avail: CASI; A99, Hardcopy; A10, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Remote Manipulator System (RMS) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. The results of that comparison for the Orbiter RMS hardware are documented. The IOA product for the RMS analysis consisted of 604 failure mode worksheets that resulted in 458 potential critical items being identified. Comparison was made to the NASA baseline which consisted of 45 FMEAs and 321 CIL items. This comparison produced agreement on all but 154 FMEAs which caused differences in 137 CIL items.

CASI

Failure Modes; Man Machine Systems; Remote Manipulator System; Space Shuttle Orbiters; Spacecraft Reliability

19900001649 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the EPD and C/remote manipulator system FMEA/CIL

Robinson, W. W., McDonnell-Douglas Astronautics Co., USA; Mar 4, 1988; 471p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185583; NAS 1.26:185583; REPT-1.0-WP-VA88003-35; Avail: CASI; A20, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Electrical Power Distribution and Control (EPD and C)/Remote Manipulator System (RMS) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA analysis of the EPD and C/RMS hardware initially generated 345 failure mode worksheets and identified 117 Potential Critical Items (PCIs) before starting the assessment process. These analysis results were compared to the proposed NASA Post 51-L baseline of 132 FMEAs and 66 CIL items.

CASI

Control Systems Design; Failure Modes; Manipulators; Remote Manipulator System; Space Shuttle Orbiters; Spacecraft Reliability

19900001650 McDonnell-Douglas Corp., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the landing/deceleration (LDG/DEC) subsystem FMEA/CIL

O'Donnell, R. A., McDonnell-Douglas Corp., USA; Weissinger, D., McDonnell-Douglas Corp., USA; Mar 18, 1988; 379p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185570; NAS 1.26:185570; REPT-1.0-WP-VA88003-43; Avail: CASI; A17, Hardcopy; A03, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Landing/Deceleration (LDG/DEC) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter LDG/DEC hardware. The IOA product for the LDG/DEC analysis consisted of 259 failure mode worksheets that resulted in 124 potential critical items being identified. Comparison was made to the NASA baseline which consisted of 267 FMEA's and 120 CIL items. This comparison produced agreement on all but 75 FMEA's which caused differences in 51 CIL items.

CASI

Deceleration; Failure Modes; Landing Gear; Space Shuttle Orbiters; Spacecraft Landing; Spacecraft Reliability

19900001651 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the communication and tracking subsystem

Gardner, J. R., McDonnell-Douglas Astronautics Co., USA; Robinson, W. M., McDonnell-Douglas Astronautics Co., USA; Trahan, W. H., McDonnell-Douglas Astronautics Co., USA; Daley, E. S., McDonnell-Douglas Astronautics Co., USA; Long, W. C., McDonnell-Douglas Astronautics Co., USA; Dec 31, 1987; 1025p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185582; NAS 1.26:185582; REPT-1.0-WP-VA87001-09; Avail: CASI; A99, Hardcopy; A10, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Orbiter Communication and Tracking hardware. The IOA analysis process utilized available Communication and Tracking hardware drawings and schematics for defining hardware assemblies, components, and hardware items. Each level of hardware

was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode.

CASI

Communication Equipment; Component Reliability; Failure Modes; Space Shuttle Orbiters; Spacecraft Instruments; Spacecraft Reliability; Tracking (Position)

19900001652 McDonnell-Douglas Corp., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the body flap subsystem FMEA/CIL

Wilson, R. E., McDonnell-Douglas Corp., USA; Feb 5, 1988; 92p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185575; NAS 1.26:185575; REPT-1.0-WP-VA88003-04; Avail: CASI; A05, Hardcopy; A01, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Body Flap (BF) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter BF hardware. The IOA product for the BF analysis consisted of 43 failure mode worksheets that resulted in 19 potential critical items being identified. Comparison was made to the NASA baseline which consisted of 34 FMEAs and 15 CIL items. This comparison produced agreement on all CIL items. Based on the Pre 51-L baseline, all non-CIL FMEAs were also in agreement.

CASI

Electronic Control; Failure Modes; Flaps (Control Surfaces); Space Shuttle Orbiters; Spacecraft Reliability; System Failures

19900001653 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the purge, vent and drain subsystem

Bynum, M. C., III, McDonnell-Douglas Astronautics Co., USA; Nov 18, 1987; 97p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185547; NAS 1.26:185547; REPT-1.0-WP-VA87001-04; Avail: CASI; A05, Hardcopy; A02, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Orbiter PV and D (Purge, Vent and Drain) Subsystem hardware. The PV and D Subsystem controls the environment of unpressurized compartments and window cavities, senses hazardous gases, and purges Orbiter/ET Disconnect. The subsystem is divided into six systems: Purge System (controls the environment of unpressurized structural compartments); Vent System (controls the pressure of unpressurized compartments); Drain System (removes water from unpressurized compartments); Hazardous Gas Detection System (HGDS) (monitors hazardous gas concentrations); Window Cavity Conditioning System (WCCS) (maintains clear windows and provides pressure control of the window cavities); and External Tank/Orbiter Disconnect Purge System (prevents cryo-pumping/icing of disconnect hardware). Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. Four of the sixty-two failure modes analyzed were determined as single failures which could result in the loss of crew or vehicle. A possible loss of mission could result if any of twelve single failures occurred. Two of the criticality 1/1 failures are in the Window Cavity Conditioning System (WCCS) outer window cavity, where leakage and/or restricted flow will cause failure to depressurize/repressurize the window cavity. Two criticality 1/1 failures represent leakage and/or restricted flow in the Orbiter/ET disconnect purge network which prevent cryopumping/icing of disconnect hardware. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode.

CASI

Drainage; Failure Modes; Gas Detectors; Purging; Space Shuttle Orbiters; Spacecraft Reliability; Venting

19900001654 McDonnell-Douglas Corp., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the elevon actuator subsystem FMEA/CIL

Wilson, R. E., McDonnell-Douglas Corp., USA; Feb 5, 1988; 60p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185578; NAS 1.26:185578; REPT-1.0-WP-VA88003-05; Avail: CASI; A04, Hardcopy; A01, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Elevon Subsystem hardware, generating draft failure modes, and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter Elevon hardware. The IOA product for the Elevon analysis consisted of 25 failure mode worksheets that resulted in 17 potential critical items being identified. Comparison was made to the NASA FMEA/CIL, which consisted of 23 FMEAs and 13 CIL items. This comparison produced agreement on all CIL items. Based on the Pre 51-L baseline, all non-CIL FMEAs were also in agreement.

CASI

Actuators; Elevons; Failure Modes; Space Shuttle Orbiters; Spacecraft Reliability; System Failures

19900001655 McDonnell-Douglas Corp., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the crew equipment subsystem

Saxon, H., McDonnell-Douglas Corp., USA; Richard, Bill, McDonnell-Douglas Corp., USA; Sinclair, S. K., McDonnell-Douglas Corp., USA; Feb 12, 1988; 591p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185577; NAS 1.26:185577; REPT-1.0-WP-VA88005-07; Avail: CASI; A25, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Crew Equipment hardware, generating draft failure modes and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter Crew Equipment hardware. The IOA product for the Crew Equipment analysis consisted of 352 failure mode worksheets that resulted in 78 potential critical items being identified. Comparison was made to the NASA baseline which consisted of 351 FMEAs and 82 CIL items.

CASI

Extravehicular Activity; Failure Modes; Space Shuttle Orbiters; Space Suits; Spacecraft Reliability; Spacecrews

19900001656 McDonnell-Douglas Corp., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of instrumental subsystem FMEA/CIL

Gardner, J. R., McDonnell-Douglas Corp., USA; Addis, A. W., McDonnell-Douglas Corp., USA; Feb 18, 1988; 190p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185572; NAS 1.26:185572; REPT-1.0-WP-VA88003-07; Avail: CASI; A09, Hardcopy; A02, Microfiche

The McDonnell Douglas Astronautics Company (MDAC) was selected in June 1986 to perform an Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL). The IOA effort first completed an analysis of the Instrumentation hardware, generating draft failure modes and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline. A resolution of each discrepancy from the comparison is provided through additional analysis as required. The results of that comparison for the Orbiter Instrumentation hardware are documented. The IOA product for Instrumentation analysis consisted of 107 failure mode worksheets that resulted in 22 critical items being identified. Comparison was made to the Pre 51-L NASA baseline with 14 Post 51-L FMEAs added,

which consists of 96 FMEAs and 18 CIL items. This comparison produced agreement on all but 25 FMEAs which caused differences in 5 CIL items.

CASI

Control Equipment; Failure Modes; In-Flight Monitoring; Space Shuttle Orbiters; Spacecraft Instruments; Spacecraft Reliability

19900001657 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support, Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the backup flight system FMEA/CIL

Prust, E. E., McDonnell-Douglas Astronautics Co., USA; Ewell, J. J., Jr., McDonnell-Douglas Astronautics Co., USA; Hinsdale, L. W., McDonnell-Douglas Astronautics Co., USA; Feb 22, 1988; 87p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185566; NAS 1.26:185566; REPT-1.0-WP-VA88003-17; Avail: CASI; A05, Hardcopy; A01, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Backup Flight System (BFS) hardware, generating draft failure modes and Potential Critical Items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the proposed NASA Post 51-L FMEA/CIL baseline. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter BFS hardware. The IOA product for the BFS analysis consisted of 29 failure mode worksheets that resulted in 21 Potential Critical Items (PCI) being identified. This product was originally compared with the proposed NASA BFS baseline and subsequently compared with the applicable Data Processing System (DPS), Electrical Power Distribution and Control (EPD and C), and Displays and Controls NASA CIL items. The comparisons determined if there were any results which had been found by the IOA but were not in the NASA baseline. The original assessment determined there were numerous failure modes and potential critical items in the IOA analysis that were not contained in the NASA BFS baseline. Conversely, the NASA baseline contained three FMEAs (IMU, ADTA, and Air Data Probe) for CIL items that were not identified in the IOA product.

CASI

Air Data Systems; Backups; Controllers; Failure Modes; Flight Control; Space Shuttle Orbiters; Spacecraft Reliability

19900001658 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support, Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the manned maneuvering unit

Huynh, M., McDonnell-Douglas Astronautics Co., USA; Duffy, R. E., McDonnell-Douglas Astronautics Co., USA; Saiidi, M. J., McDonnell-Douglas Astronautics Co., USA; Feb 12, 1988; 326p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185564; NAS 1.26:185564; REPT-1.0-WP-VA88003-11; Avail: CASI; A15, Hardcopy; A03, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Manned Maneuvering Unit (MMU) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the proposed Martin Marietta FMEA/CIL Post 51-L updates. A discussion of each discrepancy from the comparison is provided through additional analysis as required. These discrepancies were flagged as issues, and recommendations were made based on the FMEA data available at the time. The results of this comparison for the Orbiter MMU hardware are documented. The IOA product for the MMU analysis consisted of 204 failure mode worksheets that resulted in 95 potential critical items being identified. Comparison was made to the NASA baseline which consisted of 179 FMEAs and 110 CIL items. This comparison produced agreement on all 121 FMEAs which caused differences in 92 CIL items.

CASI

Failure Modes; Manned Maneuvering Units; Propulsion System Configurations; Space Shuttle Orbiters; Spacecraft Reliability

19900001659 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support, Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the rudder/speed brake subsystem FMEA/CIL

Wilson, R. E., McDonnell-Douglas Astronautics Co., USA; Feb 5, 1988; 99p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185558; NAS 1.26:185558; REPT-1.0-WP-VA88003-08; Avail: CASI; A05, Hardcopy; A02, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Rudder/Speed Brake (RSB) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline along with the proposed Post 51-L CIL updates included. A resolution of each discrepancy from the comparison was provided through additional analysis as required. This report documents the results of that comparison for the Orbiter RSB hardware. The IOA product for the RSB analysis consisted of 38 failure mode worksheets that resulted in 27 potential critical items being identified. Comparison was made to the NASA baseline which consisted of 34 FMEAs and 18 CIL items. This comparison produced agreement on all CIL items. Based on the Pre 51-L baseline, all non-CIL FMEAs were also in agreement.

CASI

Aerial Rudders; Brakes (For Arresting Motion); Failure Modes; Space Shuttle Orbiters; Spacecraft Control; Spacecraft Reliability

19900001660 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the auxiliary power unit

Barnes, J. E., McDonnell-Douglas Astronautics Co., USA; Feb 19, 1988; 452p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185580; NAS 1.26:185580; REPT-1.0-WP-VA88003-010; Avail: CASI; A20, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Auxiliary Power Unit (APU) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter APU hardware. The IOA product for the APU analysis, covering both APU hardware and APU electrical components, consisted of 344 failure mode worksheets that resulted in 178 potential critical items being identified. A comparison was made of the IOA product to the NASA APU hardware FMEA/CIL baseline which consisted of 184 FMEAs and 57 CIL items. The comparison identified 72 discrepancies.

CASI

Auxiliary Power Sources; Failure Modes; Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability

19900001661 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the life support and airlock support systems, volume 1

Arbet, J. D., McDonnell-Douglas Astronautics Co., USA; Duffy, R. E., McDonnell-Douglas Astronautics Co., USA; Barickman, K., McDonnell-Douglas Astronautics Co., USA; Saiedi, M. J., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 566p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185581-VOL-1; NAS 1.26:185581-VOL-1; REPT-1.0-WP-VA88003-19-VOL-1; Avail: CASI; A24, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Life Support and Airlock Support Systems (LSS and ALSS) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. The discrepancies were flagged for potential future resolution. This report documents the results of that comparison for the Orbiter LSS and ALSS hardware. The IOA product for the LSS and ALSS analysis consisted of 511 failure mode worksheets that resulted in 140 potential critical items. Comparison was made to the NASA baseline which consisted of 456 FMEAs and 101 CIL items. The IOA analysis identified 39 failure modes, 6 of which were classified as CIL items, for components not covered by the NASA FMEAs. It was recommended

that these failure modes be added to the NASA FMEA baseline. The overall assessment produced agreement on all but 301 FMEAs which caused differences in 111 CIL items.

CASI

Air Locks; Airlock Modules; Failure Modes; Life Support Systems; Space Shuttle Orbiters; Spacecraft Environments; Spacecraft Reliability

19900001662 McDonnell-Douglas Astronautics Co., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the life support and airlock support systems, volume 2

Barickman, K., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 317p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185581-VOL-2; NAS 1.26:185581-VOL-2; REPT-1.0-WP-VA88003-19-VOL-2; Avail: CASI; A14, Hardcopy; A03, Microfiche

The McDonnell Douglas Astronautics Company (MDAC) was selected in June 1986 to perform an Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL). The IOA effort first completed an analysis of the Life Support and Airlock Support Systems (LSS and ALSS) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. The discrepancies were flagged for potential future resolution. This report documents the results of that comparison for the Orbiter LSS and ALSS hardware. Volume 2 continues the presentation of IOA worksheets and contains the critical items list and NASA FMEA to IOA worksheet cross reference and recommendations.

CASI

Air Locks; Airlock Modules; Failure Modes; Life Support Systems; Space Shuttle Orbiters; Spacecraft Environments; Spacecraft Reliability

19900001663 McDonnell-Douglas Corp., Space Transportation System Engineering and Operations Support., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the active thermal control system

Sinclair, S. K., McDonnell-Douglas Corp., USA; Feb 12, 1988; 510p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185573; NAS 1.26:185573; REPT-1.0-WP-VA88005-06; Avail: CASI; A22, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Active Thermal Control System (ATCS) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the available NASA FMEA/CIL data. Discrepancies from the comparison were documented, and where enough information was available, recommendations for resolution of the discrepancies were made. This report documents the results of that comparison for the Orbiter ATCS hardware. The IOA product for the ATCS independent analysis consisted of 310 failure mode worksheets that resulted in 101 potential critical items (PCI) being identified. A comparison was made to the available NASA data which consisted of 252 FMEAs and 109 CIL items.

CASI

Active Control; Failure Modes; Space Shuttle Orbiters; Spacecraft Reliability; Spacecraft Temperature; Temperature Control

19900002458 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the displays and controls subsystem

Trahan, W. H., McDonnell-Douglas Astronautics Co., USA; Prust, E. E., McDonnell-Douglas Astronautics Co., USA; Dec 1, 1987; 182p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185563; NAS 1.26:185563; REPT-1.0-WP-VA87001-06; Avail: CASI; A09, Hardcopy; A02, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results

contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Orbiter Displays and Controls (D and C) subsystem hardware. The function of the D and C hardware is to provide the crew with the monitor, command, and control capabilities required for management of all normal and contingency mission and flight operations. The D and C hardware for which failure modes analysis was performed consists of the following: Acceleration Indicator (G-METER); Head Up Display (HUD); Display Driver Unit (DDU); Alpha/Mach Indicator (AMI); Horizontal Situation Indicator (HSI); Attitude Director Indicator (ADI); Propellant Quantity Indicator (PQI); Surface Position Indicator (SPI); Altitude/Vertical Velocity Indicator (AVVI); Caution and Warning Assembly (CWA); Annunciator Control Assembly (ACA); Event Timer (ET); Mission Timer (MT); Interior Lighting; and Exterior Lighting. Each hardware item was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode.

CASI

Display Devices; Failure Modes; Flight Instruments; Flight Operations; Space Shuttle Orbiters; Spacecraft Control; Spacecraft Instruments; Spacecraft Reliability

19900002459 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the orbiter main propulsion system FMEA/CIL, volume 1

Slaughter, B. C., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 623p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185559-VOL-1; NAS 1.26:185559-VOL-1; REPT-1.0-WP-VA88003-33-VOL-1; Avail: CASI; A99, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Main Propulsion System (MPS) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to available data from the Rockwell Downey/NASA JSC FMEA/CIL review. The Orbiter MPS is composed of the Propellant Management Subsystem (PMS) consisting of the liquid oxygen (LO2) and liquid hydrogen (LH2) subsystems and the helium subsystem. The PMS is a system of manifolds, distribution lines, and valves by which the liquid propellants pass from the External Tank to the Space Shuttle Main Engine (SSME). The helium subsystem consists of a series of helium supply tanks and their associated regulators, control valves, and distribution lines. Volume 1 contains the MPS description, assessment results, ground rules and assumptions, and some of the IOA worksheets.

CASI

Failure Modes; Fluid Management; Fuel Control; Fuel Systems; Propellant Transfer; Propulsion System Configurations; Space Shuttle Main Engine; Space Shuttle Orbiters; Spacecraft Propulsion; Spacecraft Reliability

19900002460 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the main propulsion subsystem FMEA/CIL, volume 2

Holden, K. A., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 572p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185559-VOL-2; NAS 1.26:185559-VOL-2; REPT-1.0-WP-VA88003-33-VOL-2; Avail: CASI; A24, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Main Propulsion System (MPS) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to available data from the Rockwell Downey/NASA JSC FMEA/CIL review. Volume 2 continues the presentation of IOA worksheets for MPS hardware items.

CASI

Failure Modes; Fluid Management; Fuel Control; Fuel Systems; Propellant Transfer; Propulsion System Configurations; Space Shuttle Main Engine; Space Shuttle Orbiters; Spacecraft Propulsion; Spacecraft Reliability

19900002461 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the main propulsion subsystem FMEA/CIL, volume 3

Holden, K. A., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 566p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185559-VOL-3; NAS 1.26:185559-VOL-3; REPT-1.0-WP-VA88003-33-VOL-3; Avail: CASI; A24,

Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Main Propulsion System (MPS) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to available data from the Rockwell Downey/NASA JSC FMEA/CIL review. Volume 3 continues the presentation of IOA worksheets and includes the potential critical items list.

CASI

Failure Modes; Fluid Management; Fuel Control; Fuel Systems; Propellant Transfer; Propulsion System Configurations; Space Shuttle Main Engine; Space Shuttle Orbiters; Spacecraft Propulsion; Spacecraft Reliability

19900002462 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the main propulsion subsystem FMEA/CIL, volume 4

Slaughter, B. C., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 511p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185559-VOL-4; NAS 1.26:185559-VOL-4; REPT-1.0-WP-VA88003-33-VOL-4; Avail: CASI; A22, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Main Propulsion System (MPS) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to available data from the Rockwell Downey/NASA JSC FMEA/CIL review. Volume 4 contains the IOA analysis worksheets and the NASA FMEA to IOA worksheet cross reference and recommendations.

CASI

Failure Modes; Fluid Management; Fuel Control; Fuel Systems; Propellant Transfer; Propulsion System Configurations; Space Shuttle Main Engine; Space Shuttle Orbiters; Spacecraft Propulsion; Spacecraft Reliability

19900002463 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the electrical power distribution and control subsystem, volume 1

Schmeckpeper, K. R., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 682p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185557-VOL-1; NAS 1.26:185557-VOL-1; REPT-1.0-WP-VA88003-23-VOL-1; Avail: CASI; A99, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA first completed an analysis of the Electrical Power Distribution and Control (EPD and C) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter EPD and C hardware. The IOA product for the EPD and C analysis consisted of 1671 failure mode analysis worksheets that resulted in 468 potential critical items being identified. Comparison was made to the proposed NASA Post 51-L baseline which consisted of FMEAs and 158 CIL items. Volume 1 contains the EPD and C subsystem description, analysis results, ground rules and assumptions, and some of the IOA worksheets.

CASI

Control Systems Design; Failure Modes; Power Modules (STS); Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability

19900002464 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the electrical power distribution and control subsystem, volume 2

Schmeckpeper, K. R., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 652p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185557-VOL-2; NAS 1.26:185557-VOL-2; REPT-1.0-WP-VA88003-23-VOL-2; Avail: CASI; A99,

Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA first completed an analysis of the Electrical Power Distribution and Control (EPD and C) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter EPD and C hardware. Volume 2 continues the presentation of IOA worksheets.

CASI

Control Systems Design; Failure Modes; Power Modules (STS); Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability

19900002465 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the electrical power distribution and control subsystem, volume 3

Schmeckpeper, K. R., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 651p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185557-VOL-3; NAS 1.26:185557-VOL-3; REPT-1.0-WP-VA88003-23-VOL-3; Avail: CASI; A99, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA first completed an analysis of the Electrical Power Distribution and Control (EPD and C) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter EPD and C hardware. Volume 3 continues the presentation of IOA worksheets and contains the potential critical items list and the NASA FMEA to IOA worksheet cross reference and recommendations.

CASI

Control Systems Design; Failure Modes; Power Modules (STS); Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability

19900002466 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the active thermal control subsystem

Sinclair, S. K., McDonnell-Douglas Astronautics Co., USA; Parkman, W. E., McDonnell-Douglas Astronautics Co., USA; Dec 1, 1987; 375p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185553; NAS 1.26:185553; REPT-1.0-WP-VA87001-05; Avail: CASI; A16, Hardcopy; A03, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical (PCIs) items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The independent analysis results corresponding to the Orbiter Active Thermal Control Subsystem (ATCS) are documented. The major purpose of the ATCS is to remove the heat, generated during normal Shuttle operations from the Orbiter systems and subsystems. The four major components of the ATCS contributing to the heat removal are: Freon Coolant Loops; Radiator and Flow Control Assembly; Flash Evaporator System; and Ammonia Boiler System. In order to perform the analysis, the IOA process utilized available ATCS hardware drawings and schematics for defining hardware assemblies, components, and hardware items. Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. Of the 310 failure modes analyzed, 101 were determined to be PCIs.

CASI

Active Control; Failure Modes; Heat Radiators; Space Shuttle Orbiters; Space Transportation System Flights; Spacecraft Reliability; Temperature Control

19900002467 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): FMEA/CIL assessment *Topical Interim Report*

Saiidi, Mo J., McDonnell-Douglas Astronautics Co., USA; Swain, L. J., McDonnell-Douglas Astronautics Co., USA; Compton, J. M., McDonnell-Douglas Astronautics Co., USA; Mar 9, 1988; 100p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185550; NAS 1.26:185550; REPT-1.0-WP-VA88003-40; Avail: CASI; A05, Hardcopy; A02, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. Direction was given by the Orbiter and GFE Projects Office to perform the hardware analysis and assessment using the instructions and ground rules defined in NSTS 22206. The IOA analysis features a top-down approach to determine hardware failure modes, criticality, and potential critical items. to preserve independence, the analysis was accomplished without reliance upon the results contained within the NASA and prime contractor FMEA/CIL documentation. The assessment process compares the independently derived failure modes and criticality assignments to the proposed NASA Post 51-L FMEA/CIL documentation. When possible, assessment issues are discussed and resolved with the NASA subsystem managers. The assessment results for each subsystem are summarized. The most important Orbiter assessment finding was the previously unknown stuck autopilot push-button criticality 1/1 failure mode, having a worst case effect of loss of crew/vehicle when a microwave landing system is not active.

CASI

Automatic Pilots; Failure Modes; Microwave Landing Systems; Space Shuttle Orbiters; Spacecraft Reliability

19900002468 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the guidance, navigation, and control subsystem FMEA/CIL

Trahan, W. H., McDonnell-Douglas Astronautics Co., USA; Odonnell, R. A., McDonnell-Douglas Astronautics Co., USA; Pietz, K. C., McDonnell-Douglas Astronautics Co., USA; Drapela, L. J., McDonnell-Douglas Astronautics Co., USA; Jan 23, 1988; 273p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185552; NAS 1.26:185552; REPT-1.0-WP-VA88003-06; Avail: CASI; A12, Hardcopy; A03, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Guidance, Navigation, and Control System (GNC) hardware, generating draft failure modes and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. The results of that comparison for the Orbiter GNC hardware is documented. The IOA product for the GNC analysis consisted of 141 failure mode worksheets that resulted in 24 potential critical items being identified. Comparison was made to the NASA baseline which consisted of 148 FMEAs and 36 CIL items. This comparison produced agreement on all but 56 FMEAs which caused differences in zero CIL items.

CASI

Failure Modes; Space Navigation; Space Shuttle Orbiters; Spacecraft Guidance; Spacecraft Reliability

19900002469 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the Electrical Power Distribution and Control/Electrical Power Generation (EPD and C/EPG) FMEA/CIL

Mccants, C. N., McDonnell-Douglas Astronautics Co., USA; Bearrow, M., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 444p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185542; NAS 1.26:185542; REPT-1.0-WP-VA88003-33; Avail: CASI; A19, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Electrical Power Distribution and Control/Electrical Power Generation (EPD and C/EPG) hardware, generating draft failure modes and potential critical items. to preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison was provided through additional analysis as required. The results

of that comparison is documented for the Orbiter EPD and C/EPG hardware. The IOA product for the EPD and C/EPG analysis consisted of 263 failure mode worksheets that resulted in 42 potential critical items being identified. Comparison was made to the NASA baseline which consisted of 211 FMEA and 47 CIL items.

CASI

Electric Generators; Failure Modes; Space Shuttle Orbiters; Spacecraft Power Supplies; Spacecraft Reliability

19900002470 McDonnell-Douglas Astronautics Co., Engineering Services., Houston, TX, USA

Independent Orbiter Assessment (IOA): Analysis of the life support and airlock support subsystems

Arbet, Jim, McDonnell-Douglas Astronautics Co., USA; Duffy, R., McDonnell-Douglas Astronautics Co., USA; Barickman, K., McDonnell-Douglas Astronautics Co., USA; Saiidi, Mo J., McDonnell-Douglas Astronautics Co., USA; Nov 2, 1987; 594p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185539; NAS 1.26:185539; REPT-1.0-WP-VA87001-02; Avail: CASI; A25, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Orbiter Life Support System (LSS) and Airlock Support System (ALSS). Each level of hardware was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. The LSS provides for the management of the supply water, collection of metabolic waste, management of waste water, smoke detection, and fire suppression. The ALSS provides water, oxygen, and electricity to support an extravehicular activity in the airlock.

CASI

Air Locks; Failure Modes; Life Support Systems; Space Shuttle Orbiters; Spacecraft Components; Spacecraft Reliability; System Failures

19900002471 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the orbital maneuvering system FMEA/CIL, volume 1

Prust, Chet D., McDonnell-Douglas Astronautics Co., USA; Haufler, W. A., McDonnell-Douglas Astronautics Co., USA; Marino, A. J., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 618p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185544-VOL-1; NAS 1.26:185544-VOL-1; REPT-1.0-WP-VA88003-30-VOL-1; Avail: CASI; A99, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Orbital Maneuvering System (OMS) hardware and Electrical Power Distribution and Control (EPD and C), generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the proposed Post 51-L NASA FMEA/CIL baseline. This report documents the results of that comparison for the Orbiter OMS hardware. The IOA analysis defined the OMS as being comprised of the following subsystems: helium pressurization, propellant storage and distribution, Orbital Maneuvering Engine, and EPD and C. The IOA product for the OMS analysis consisted of 284 hardware and 667 EPD and C failure mode worksheets that resulted in 160 hardware and 216 EPD and C potential critical items (PCIs) being identified. A comparison was made of the IOA product to the NASA FMEA/CIL baseline which consisted of 101 hardware and 142 EPD and C CIL items.

CASI

Failure Modes; Orbit Maneuvering Engine (Space Shuttle); Propellant Storage; Space Shuttle Orbiters; Spacecraft Reliability

19900002472 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the orbital maneuvering subsystem, volume 2

Haufler, W. A., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 601p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185544-VOL-2; NAS 1.26:185544-VOL-2; REPT-1.0-WP-VA88003-30-VOL-2; Avail: CASI; A99, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Orbital Maneuvering System (OMS) hardware and electrical power distribution and control (EPD and C), generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the proposed Post 51-L NASA FMEA/CIL baseline. This report documents the results of that comparison for the Orbiter OMS hardware and EPD and C systems. Volume 2 continues the presentation of IOA worksheets and contains the critical items list and the NASA FMEA to IOA worksheet cross reference and recommendations.

CASI

Failure Modes; Orbit Maneuvering Engine (Space Shuttle); Space Shuttle Orbiters; Spacecraft Reliability

19900002473 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the communication and tracking subsystem, volume 1

Long, W. C., McDonnell-Douglas Astronautics Co., USA; Mar 18, 1988; 652p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185528-VOL-1; NAS 1.26:185528-VOL-1; REPT-1.0-WP-VA88005-10-VOL-1; Avail: CASI; A99, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Communication and Tracking hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter Communication and Tracking hardware. The IOA product for the Communication and Tracking consisted of 1,108 failure mode worksheets that resulted in 298 critical items being identified. Comparison was made to the NASA baseline which consists of 697 FMEAs and 239 CIL items. The comparison determined if there were any results which had been found by IOA but were not in the NASA baseline. This comparison produced agreement on all but 407 FMEAs which caused differences in 294 CIL items. Volume 1 contains the subsystem description, assessment results, ground rules and assumptions, and some of the IOA worksheets.

CASI

Communication Equipment; Data Links; Failure Modes; Radio Communication; Space Detection and Tracking System; Space Shuttle Orbiters; Spacecraft Communication; Spacecraft Reliability; Spacecraft Tracking

19900002474 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the communication and tracking subsystem, volume 2

Long, W. C., McDonnell-Douglas Astronautics Co., USA; Mar 18, 1988; 602p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185528-VOL-2; NAS 1.26:185528-VOL-2; REPT-1.0-WP-VA88005-10-VOL-2; Avail: CASI; A99, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Communication and Tracking hardware, generating draft failure modes and potential critical items. The IOA results were then compared to the NASA FMEA/CIL baseline. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter Communication and Tracking hardware. Volume 2 continues the presentation of IOA worksheets.

CASI

Communication Equipment; Data Links; Failure Modes; Radio Communication; Space Detection and Tracking System; Space Shuttle Orbiters; Spacecraft Communication; Spacecraft Reliability; Spacecraft Tracking

19900002475 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the communication and tracking subsystem, volume 3

Long, W. C., McDonnell-Douglas Astronautics Co., USA; Mar 18, 1988; 545p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185528-VOL-3; NAS 1.26:185528-VOL-3; REPT-1.0-WP-VA88005-10-VOL-3; Avail: CASI; A23, Hardcopy; A04, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Communication and Tracking hardware, generating draft failure modes and potential critical items. The IOA results were then compared to the NASA FMEA/CIL baseline. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter Communication and Tracking hardware. Volume 3 continues the presentation of IOA worksheets and contains the potential critical items list, detailed analysis, and the NASA FMEA to IOA worksheet cross reference and recommendations.

CASI

Communication Equipment; Data Links; Failure Modes; Radio Communication; Space Detection and Tracking System; Space Shuttle Orbiters; Spacecraft Communication; Spacecraft Reliability; Spacecraft Tracking

19900002476 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the hydraulics/water spray boiler subsystem

Bynum, M. C., McDonnell-Douglas Astronautics Co., USA; Duval, J. D., McDonnell-Douglas Astronautics Co., USA; Parkman, W. E., McDonnell-Douglas Astronautics Co., USA; Davidson, W. R., McDonnell-Douglas Astronautics Co., USA; Mar 2, 1988; 619p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185537; NAS 1.26:185537; Avail: CASI; A99, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the Hydraulics/Water Spray Boiler (HYD/WSB) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the NASA FMEA/CIL baseline with proposed Post 51-L updates included. A resolution of each discrepancy from the comparison is provided through additional analysis as required. This report documents the results of that comparison for the Orbiter HYD/WSB hardware. The IOA product for the HYD/WSB analysis consisted of 447 failure mode worksheets that resulted in 183 potential critical items being identified. Comparison was made to the NASA baseline which consisted of 364 FMEAs and 111 CIL items. This comparison produced agreement on all but 68 FMEAs which caused differences in 23 CIL items.

CASI

Boilers; Failure Modes; Hydraulic Control; Hydraulic Equipment; Space Shuttle Orbiters; Spacecraft Reliability

19900002477 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the reaction control system, volume 1

Prust, Chet D., McDonnell-Douglas Astronautics Co., USA; Hartman, Dan W., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 882p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185543-VOL-1; NAS 1.26:185543-VOL-1; REPT-1.0-WP-VA88003-12-VOL-1; Avail: CASI; A99, Hardcopy; A10, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the aft and forward Reaction Control System (RCS) hardware, and Electrical Power Distribution and Control (EPD and C), generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the proposed Post 51-L NASA FMEA/CIL baseline. This report documents the results of that comparison for the Orbiter RCS hardware and EPD and C systems. The IOA product for the RCS analysis consisted of 208 hardware and 2064 EPD and C failure mode worksheets that resulted in 141 hardware and 449 EPD and C potential critical items (PCIs) being identified. A comparison was made of the IOA product to the NASA FMEA/CIL baseline. After comparison and discussions with the NASA subsystem manager, 96 hardware issues, 83 of which concern CIL items or PCIs, and 280 EPD and C issues, 158 of which concern CIL items or PCIs, and 280 EPD and C issues, 158 of which concern CIL items or PCIs, remain unresolved. Volume 1 contains the subsystem description, assessment results, and some of the IOA worksheets.

CASI

Controllers; Electric Power Transmission; Failure Modes; Helium; Pressurizing; Propellant Storage; Rocket Engines; Space Shuttle Orbiters; Spacecraft Maneuvers; Spacecraft Power Supplies; Spacecraft Propulsion; Spacecraft Reliability

19900002478 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the reaction control system, volume 2

Prust, Chet D., McDonnell-Douglas Astronautics Co., USA; Hartman, Dan W., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 702p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185543-VOL-2; NAS 1.26:185543-VOL-2; REPT-1.0-WP-VA88003-12-VOL-2; Avail: CASI; A99, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the aft and forward Reaction Control System (RCS) hardware and Electrical Power Distribution and Control (EPD and C), generating draft failure modes and potential critical items. The IOA results were then compared to the proposed Post 51-L NASA FMEA/CIL baseline. This report documents the results of that comparison for the Orbiter RCS hardware and EPD and C systems. Volume 2 continues the presentation of IOA worksheets. CASI

Controllers; Electric Power Transmission; Helium; Pressurizing; Propellant Storage; Rocket Engines; Space Shuttle Orbiters; Spacecraft Maneuvers; Spacecraft Power Supplies; Spacecraft Propulsion; Spacecraft Reliability

19900002479 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the reaction control system, volume 3

Prust, Chet D., McDonnell-Douglas Astronautics Co., USA; Hartman, Dan W., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 803p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185543-VOL-3; NAS 1.26:185543-VOL-3; REPT-1.0-WP-VA88003-12-VOL-3; Avail: CASI; A99, Hardcopy; A10, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the aft and forward Reaction Control System (RCS) hardware and Electrical Power Distribution and Control (EPD and C), generating draft failure modes and potential critical items. The IOA results were then compared to the proposed Post 51-L NASA FMEA/CIL baseline. This report documents the results of that comparison for the Orbiter RCS hardware and EPD and C systems. Volume 3 continues the presentation of IOA worksheets. CASI

Controllers; Electric Power Supplies; Failure Modes; Helium; Pressurizing; Propellant Storage; Rocket Engines; Space Shuttle Orbiters; Spacecraft Maneuvers; Spacecraft Power Supplies; Spacecraft Propulsion; Spacecraft Reliability

19900002480 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the reaction control system, volume 4

Prust, Chet D., McDonnell-Douglas Astronautics Co., USA; Hartman, Dan W., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 732p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185543-VOL-4; NAS 1.26:185543-VOL-4; REPT-1.0-WP-VA88003-12-VOL-4; Avail: CASI; A99, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the aft and forward Reaction Control System (RCS) hardware and Electrical Power Distribution and Control (EPD and C), generating draft failure modes and potential critical items. The IOA results were then compared to the proposed Post 51-L NASA FMEA/CIL baseline. This report documents the results of that comparison for the Orbiter RCS hardware and EPD and C systems. Volume 4 continues the presentation of IOA worksheets and contains the potential critical items list. CASI

Controllers; Electric Power Transmission; Failure Modes; Helium; Pressurizing; Propellant Storage; Rocket Engines; Space Shuttle Orbiters; Spacecraft Maneuvers; Spacecraft Power Supplies; Spacecraft Propulsion; Spacecraft Reliability

19900002481 McDonnell-Douglas Astronautics Co., Houston, TX, USA

Independent Orbiter Assessment (IOA): Assessment of the reaction control system, volume 5

Prust, Chet D., McDonnell-Douglas Astronautics Co., USA; Hartman, Dan W., McDonnell-Douglas Astronautics Co., USA; Feb 26, 1988; 693p; In English

Contract(s)/Grant(s): NAS9-17650

Report No.(s): NASA-CR-185543-VOL-5; NAS 1.26:185543-VOL-5; REPT-1.0-WP-VA88003-12-VOL-5; Avail: CASI; A99, Hardcopy; A06, Microfiche

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA effort first completed an analysis of the aft and forward Reaction Control System (RCS) hardware and Electrical Power Distribution and Control (EPD and C), generating draft failure modes and potential critical items. The IOA results were then compared to the proposed Post 51-L NASA FMEA/CIL baseline. This report documents the results of that comparison for the Orbiter RCS hardware and EPD and C systems. Volume 5 contains detailed analysis and superseded analysis worksheets and the NASA FMEA to IOA worksheet cross reference and recommendations.

CASI

Controllers; Electric Power Transmission; Failure Modes; Helium; Pressurizing; Propellant Storage; Rocket Engines; Space Shuttle Orbiters; Spacecraft Maneuvers; Spacecraft Power Supplies; Spacecraft Propulsion; Spacecraft Reliability

19980120592

Space Shuttle program risk management

Fragola, Joseph R., Science Applications International Corp., New York, USA; 1996, pp. 133-142; In English; Copyright; Avail: Aeroplus Dispatch

In the decade since the Challenger accident NASA has slowly undergone a paradigm shift in its approach towards the assessment of the potential for the loss of a Shuttle vehicle and crew. A recognition by NASA management of the usefulness of probabilistic risk assessment (PRA) results in the setting of priorities in Shuttle program activities convinced the NASA Office of Space Flight and Office of Safety and Mission Assurance Associate Administrators to jointly sponsor a series of educational seminars on PRA throughout the NASA facilities. Further, they agreed to undertake a comprehensive and more detailed PRA study of the Shuttle throughout all its active mission phases from launch to wheel-stop on landing. The results of this study provide a key element in a Space Shuttle risk management program which may enable the substantial cost reductions required to keep the Shuttle program viable while maintaining the Shuttle's admirable safety and reliability record.

Author (AIAA)

Space Shuttles; Failure Modes; Failure Analysis

18

SPACECRAFT DESIGN, TESTING AND PERFORMANCE

Includes satellites; space platforms; space stations; spacecraft systems and components such as thermal and environmental controls; and spacecraft control and stability characteristics. For life support systems, see 54 Man/System Technology and Life Support. For related information, see also 05 Aircraft Design, Testing and Performance, 39 Structural Mechanics, and 16 Space Transportation and Safety.

19860023040 Massachusetts Inst. of Tech., Dept. of Aeronautics and Astronautics., Cambridge, MA, USA

Reliability issues in active control of large flexible space structures *Semiannual Status Report, 16 May - 15 Nov. 1985*

Vandervelde, W. E., Massachusetts Inst. of Tech., USA; Feb 4, 1986; 14p; In English

Contract(s)/Grant(s): NAG1-126

Report No.(s): NASA-CR-179758; NAS 1.26:179758; Avail: CASI; A03, Hardcopy; A01, Microfiche

Efforts in this reporting period were centered on four research tasks: design of failure detection filters for robust performance in the presence of modeling errors, design of generalized parity relations for robust performance in the presence of modeling errors, design of failure sensitive observers using the geometric system theory of Wonham, and computational techniques for evaluation of the performance of control systems with fault tolerance and redundancy management

CASI

Control Systems Design; Errors; Failure Analysis; Failure Modes; Fault Tolerance; Redundancy; Robustness (Mathematics)

19950021309 NASA Lewis Research Center, Cleveland, OH, USA

Static stability of a three-dimensional space truss

Shaker, John F., NASA Lewis Research Center, USA; May 1, 1995; 114p; In English

Contract(s)/Grant(s): RTOP 478-42-10

Report No.(s): NASA-TM-106944; E-9679; NAS 1.15:106944; Avail: CASI; A06, Hardcopy; A02, Microfiche

In order to deploy large flexible space structures it is necessary to develop support systems that are strong and lightweight. The most recent example of this aerospace design need is vividly evident in the space station solar array assembly. In order to

accommodate both weight limitations and strength performance criteria, ABLE Engineering has developed the Folding Articulating Square Truss (FASTMast) support structure. The FASTMast is a space truss/mechanism hybrid that can provide system support while adhering to stringent packaging demands. However, due to its slender nature and anticipated loading, stability characterization is a critical part of the design process. Furthermore, the dire consequences surely to result from a catastrophic instability quickly provide the motivation for careful examination of this problem. The fundamental components of the space station solar array system are the (1) solar array blanket system, (2) FASTMast support structure, and (3) mast canister assembly. The FASTMast once fully deployed from the canister will provide support to the solar array blankets. A unique feature of this structure is that the system responds linearly within a certain range of operating loads and nonlinearly when that range is exceeded. The source of nonlinear behavior in this case is due to a changing stiffness state resulting from an inability of diagonal members to resist applied loads. The principal objective of this study was to establish the failure modes involving instability of the FASTMast structure. Also of great interest during this effort was to establish a reliable analytical approach capable of effectively predicting critical values at which the mast becomes unstable. Due to the dual nature of structural response inherent to this problem, both linear and nonlinear analyses are required to characterize the mast in terms of stability. The approach employed herein is one that can be considered systematic in nature. The analysis begins with one and two-dimensional failure models of the system and its important components. From knowledge gained through preliminary analyses a foundation is developed for three-dimensional analyses of the FASTMast structure. The three-dimensional finite element (FE) analysis presented here involves a FASTMast system one-tenth the size of the actual flight unit. Although this study does not yield failure analysis results that apply directly to the flight article, it does establish a method by which the full-scale mast can be evaluated.

Author
Failure Analysis; Failure Modes; Flexible Spacecraft; Large Space Structures; Space Erectable Structures; Space Station Structures; Structural Analysis; Structural Failure; Structural Stability; Trusses

19980123830

Highlights of the intelligent diagnosis technique for a spacecraft

Huang, W. H., Harbin Inst. of Technology, China; Xhang, J. Z., Harbin Inst. of Technology, China; Feng, Y. X., Harbin Inst. of Technology, China; Rong, J. L., Harbin Inst. of Technology, China; Ji, C. W., Harbin Inst. of Technology, China; Cheng, H. T., Harbin Inst. of Technology, China; 1995, pp. 11-17; In English; Copyright; Avail: AIAA Dispatch

The requirements of safety assurance and the features of failure diagnosis for a spacecraft are reviewed. The architecture of an intelligent diagnostic system and the techniques of diagnosis for a spacecraft are discussed and the prospects for intelligent failure diagnosis techniques for a spacecraft are examined.

Author (AIAA)

System Failures; Failure Analysis; Spacecraft Maintenance; Failure Modes

20

SPACECRAFT PROPULSION AND POWER

Includes main propulsion systems and components, e.g., rocket engines; and spacecraft auxiliary power sources. For related information, see also 07 Aircraft Propulsion and Power; 28 Propellants and Fuels; 15 Launch Vehicles and Launch Operations; and 44 Energy Production and Conversion.

19760005043 British Aircraft Corp. (Operating) Ltd., Bristol, UK

Failure mode analysis of the ROSA-DP secondary deployment unit

Design Modification and Test of a Storage and Deployment Unit for a Roll-Up Solar Array; Sep 1, 1974, pp. 59 p; In English; See also N76-12127 03-20

Report No.(s): REPT-889/BDG/ROSA/021; Avail: CASI; A04, Hardcopy, Unavail. Microfiche

The reliability analysis of the roll out solar array secondary deployment unit is presented for a flight model based on design standard. Thermal effects were accurately estimated. Failure mode effect and criticality tables were laid out and a reliability value derived from the cumulative probability of a single point failure mode discovered by this means. The implications of recent design modifications are discussed.

ESA

Failure Analysis; Failure Modes; Mechanical Drives; Reliability Analysis; Solar Arrays

19810056482

Failure modes and probability of failure of high strength steel rocket motor cases

Margetson, J., Propellants, Explosives and Rocket Motor Establishment, Aylesbury, UK; Jul 1, 1981; 10p; In English; 17th; Joint Propulsion Conference, July 27-29, 1981, Colorado Springs, CO, US; Sponsored by AIAA

Report No.(s): AIAA PAPER 81-1465; Copyright; Avail: Issuing Activity

Failure modes of high strength steel rocket motor cases are identified and analysed. An elastoplastic instability analysis is used for the thin walled sections and a criterion of ductile failure is used for the thicker interconnecting regions. A Monte Carlo simulation procedure allows the material variability to be modelled and the burst pressure distribution to be generated. The interaction between the burst pressure and the firing pressure distributions are analysed to obtain, for a prescribed level of confidence, the failure probability of the motor case.

AIAA

Critical Loading; Engine Failure; Failure Analysis; Failure Modes; High Strength Steels; Rocket Engine Cases

19820058653

System interface FMEA by Matrix method

Herrin, S. A., ESL, Inc., USA; Jan 1, 1982; 6p; In English; Annual Reliability and Maintainability Symposium, January 26-28, 1982, Los Angeles, CA; See also A82-42176 21-38; Copyright; Avail: Issuing Activity

This paper describes the application of the Matrix FMEA technique to perform a system interface analysis. A solid fuel rocket motor thermal function taken from a spacecraft design is used as an example. The methodology presented focuses on the thermal control function and the interrelationship of it to the power unit, command unit, telemetry unit, and the associated interconnecting cables and harness wiring. A step-by-step procedure for performing the analysis is presented starting with the definition of the functional configuration and interconnecting wiring and encompassing the interface wiring failure effects, the source units' failure effects, the thermal control failure effects, and the load units' interface circuitry failure effects. This method is beneficial to the matrix FMEA analyst for incorporating the interconnection circuitry failure effects into subsystem oriented FMEA analyses.

AIAA

Availability; Failure Modes; Maintainability; Matrix Methods; Reliability Engineering; Spacecraft Reliability

19850063245

Minimizing spacecraft power loss due to single-point failures

Billerbeck, W., COMSAT Laboratories, USA; Jan 1, 1984; 12p; In English; IECEC '84: Advanced energy systems - Their role in our future, August 19-24, 1984, San Francisco, CA; See also A85-45351 22-44; Copyright; Avail: Issuing Activity

The concept of failure modes and effect analysis (FMEA), in the form of a calculation of the quantitative power loss resulting from single-point failure, was used to improve designs of satellite power systems. All components of a power system were analyzed and the percent of power loss attributable to single-point failure was calculated. Then the means of controlling single-point failure, such as solar cell string isolation, cross strapping, and diode isolation, were implemented. These means of damage control were evaluated numerically to demonstrate that a certain level of power output can be maintained following a single-point fault. New bus designs, including the protected bus concept, the dual power bus, and double-insulated power bus, were developed for power systems. These new designs allowed slow power degradation and prevented single-point failures.

AIAA

Fail-Safe Systems; Failure Modes; Optimization; Power Conditioning; Satellite Design; Spacecraft Power Supplies

19870005835 Battelle Columbus Labs., Ssme Study Group., OH, USA

Studies and analyses of the Space Shuttle Main Engine: SSME failure data review, diagnostic survey and SSME diagnostic evaluation

Glover, R. C., Battelle Columbus Labs., USA; Kelley, B. A., Battelle Columbus Labs., USA; Tischer, A. E., Battelle Columbus Labs., USA; Dec 15, 1986; 348p; In English

Contract(s)/Grant(s): NASW-3737

Report No.(s): NASA-CR-178993; NAS 1.26:178993; BCD-SSME-TR-86-1; Avail: CASI; A15, Hardcopy; A03, Microfiche

The results of a review of the Space Shuttle Main Engine (SSME) failure data for the period 1980 through 1983 are presented. The data was collected, evaluated, and ranked according to procedures established during this study. A number of conclusions and recommendations are made based upon this failure data review. The results of a state-of-the-art diagnostic survey are also

presented. This survey covered a broad range of diagnostic sensors and techniques and the findings were evaluated for application to the SSME. Finally, a discussion of the initial activities for the on-going SSME diagnostic evaluation is included.

CASI

Failure Analysis; Failure Modes; Space Shuttle Main Engine; Technology Assessment

19870013332 Battelle Columbus Labs., OH, USA

Studies and analyses of the space shuttle main engine: High-pressure oxidizer turbopump failure information propagation model

Glover, R. C., Battelle Columbus Labs., USA; Rudy, S. W., Battelle Columbus Labs., USA; Tischer, A. E., Battelle Columbus Labs., USA; Apr 20, 1987; 511p; In English

Contract(s)/Grant(s): NASW-3737

Report No.(s): NASA-CR-179079; NAS 1.26:179079; BCD-SSME-TR-87-1; Avail: CASI; A22, Hardcopy; A04, Microfiche

The high-pressure oxidizer turbopump (HPOTP) failure information propagation model (FIPM) is presented. The text includes a brief discussion of the FIPM methodology and the various elements which comprise a model. Specific details of the HPOTP FIPM are described. Listings of all the HPOTP data records are included as appendices.

CASI

Failure Analysis; Failure Modes; High Pressure; Models; Space Shuttle Main Engine; Turbine Pumps

19870016664 Rockwell International Corp., Rocketdyne Div., Canoga Park, CA, USA

Concepts for space maintenance of OTV engines *Topical Interim Report*

Martinez, A., Rockwell International Corp., USA; Hines, B. D., Rockwell International Corp., USA; Erickson, C. M., Rockwell International Corp., USA; Johns Hopkins Univ., The 1986 JANNAF Propulsion Meeting, Volume 1; Aug 1, 1986, pp. p 99-110; In English; See also N87-26087 20-20

Contract(s)/Grant(s): NAS3-23773; Avail: CASI; A03, Hardcopy; A06, Microfiche

Concepts for space maintainability of the Orbital Transfer Vehicle (OTV) engines are examined. An engine design is developed which is driven by space maintenance requirements and by a failure modes and effects analysis (FMEA). Modularity within the engine is shown to offer cost benefits and improved space maintenance capabilities. Space-operable disconnects are conceptualized for both engine change-out and for module replacement. A preliminary space maintenance plan is developed around a controls and condition monitoring system using advanced sensors, controls, and condition monitoring concepts.

CASI

Engine Design; Orbit Transfer Vehicles; Rocket Engines; Space Maintenance

19890000748 Rockwell International Corp., Rocketdyne Div., Canoga Park, CA, USA

Orbit transfer rocket engine technology program. Phase 2: Advanced engine study *Topical Interim Report*

Erickson, C., Rockwell International Corp., USA; Martinez, A., Rockwell International Corp., USA; Hines, B., Rockwell International Corp., USA; Feb 1, 1987; 85p; In English

Contract(s)/Grant(s): NAS3-23773; RTOP 506-42-21

Report No.(s): NASA-CR-179602; NAS 1.26:179602; RI/RD-87-126; Avail: CASI; A05, Hardcopy; A01, Microfiche

In Phase 2 of the Advanced Engine Study, the Failure Modes and Effects Analysis (FMEA) maintenance-driven engine design, preliminary maintenance plan, and concept for space operable disconnects generated in Phase 1 were further developed. Based on the results of the vehicle contractors Orbit Transfer Vehicle (OTV) Concept Definition and System Analysis Phase A studies, minor revisions to the engine design were made. Additional refinements in the engine design were identified through further engine concept studies. These included an updated engine balance incorporating experimental heat transfer data from the Enhanced Heat Load Thrust Chamber Study and a Rao optimum nozzle contour. The preliminary maintenance plan of Phase 1 was further developed through additional studies. These included a compilation of critical component lives and life limiters and a review of the Space Shuttle Main Engine (SSME) operations and maintenance manual in order to begin outlining the overall maintenance procedures for the Orbit Transfer Vehicle Engine and identifying technology requirements for streamlining space-based operations. Phase 2 efforts also provided further definition to the advanced fluid coupling devices including the selection and preliminary design of a preferred concept and a preliminary test plan for its further development.

CASI

Hydrogen Oxygen Engines; Orbit Transfer Vehicles; Orbital Maneuvers; Orbital Servicing

19890011658 Martin Marietta Aerospace, Astronautics Group., Denver, CO, USA

Space Propulsion Hazards Analysis Manual (SPHAM), volume 1 *Final Report, Dec. 1983 - Jun. 1986*

Erdahl, David C., Martin Marietta Aerospace, USA; Banning, Douglas W., Martin Marietta Aerospace, USA; Simon, Elvis D., Martin Marietta Aerospace, USA; Oct 1, 1988; 501p; In English

Contract(s)/Grant(s): F04611-84-C-0003

Report No.(s): AD-A203204; MCR-88-590-VOL-1; AFAL-TR-88-096-VOL-1; Avail: CASI; A22, Hardcopy; A04, Microfiche

SPHAM is a compilation of methods and data directed at hazards analysis and safety for space propulsion and associated vehicles, but broadly applicable to other environments and systems. It includes methods for compiling imposed requirements and deriving design requirements. It describes in detail the steps to constructing accident scenarios for formal risk assessment. It discusses the approaches the developing probabilities for events in scenarios, and probabilities for scenarios. It illustrates data analysis from experience data for the purpose of probability modeling. The SPHAM provides methods for predicting blast, fragmentation, thermal, acoustic and toxicity post-accident environments. SPHAM describes in overview fashion a large number of qualitative and quantitative analytical methods available to perform hazards analysis complete with guidelines for application. Examples are FMEA, Fault-tree and Energy Analysis. It describes methods to organize analysis by type, phase, or subsystem. Examples are interface hazards analysis, preliminary hazards analysis, and ordnance hazards analysis. Qualitative and quantitative risk assessments are described. The formal processes for hazards analysis and safety for various agencies and departments of the government and DOD are described. The appendices to SPHAM contain voluminous data on available references in the form of an annotated bibliography, summary of the hazardous nature of 27 commodities common the space propulsion, and system descriptions for a variety of space vehicles, upper stage vehicles, and spacecraft.

DTIC

Accidents; Hazards; Launch Vehicles; Mathematical Models; Probability Theory; Risk; Space Flight; Spacecraft Propulsion

19890013279 Martin Marietta Corp., Astronautics Group., Denver, CO, USA

Space Propulsion Hazards Analysis Manual (SPHAM). Volume 2: Appendices *Final Report, Dec. 1983 - Jun. 1986*

Erdahl, David C., Martin Marietta Corp., USA; Banning, Douglas W., Martin Marietta Corp., USA; Simon, Elvis D., Martin Marietta Corp., USA; Oct 1, 1988; 1178p; In English

Contract(s)/Grant(s): F04611-84-C-0003

Report No.(s): AD-A204601; MCR-88-590-VOL-2; AFAL-TR-88-096-VOL-2; Avail: CASI; A99, Hardcopy; A10, Microfiche

The Space Propulsion Hazards Analysis manual (SPHAM) is a compilation of methods and data directed at hazards analysis and safety for space propulsion and associated vehicles, but broadly applicable to other environments and systems. It includes methods for compiling imposed requirements and deriving design requirements. It describes in detail the steps to constructing accident scenarios for formal risk assessment. It discusses the approaches to developing probabilities for events in scenarios, and probabilities for scenarios. It illustrates data analysis from experience data for the purpose of probability modeling. The SPHAM provides methods for predicting blast, fragmentation, thermal, acoustic and toxicity post accident environments. The SPHAM describes in overview fashion a large number of qualitative and quantitative analytical methods available to perform hazards analysis complete with guidelines for application. Examples are FMEA, Fault-tree and Energy Analysis. It describes methods to organize analysis by type, phase, or subsystem. Examples are interface hazards analysis, preliminary hazards analysis, and ordnance hazards analysis. Qualitative and quantitative risk assessments are described. The appendices to SPHAM contain voluminous data on available references in the form of an annotated bibliography, summary of the hazardous nature of 27 commodities common to space propulsion, and system description for a variety of space launch vehicles, upper stage vehicles, and spacecraft.

DTIC

Accidents; Aerospace Safety; Data Processing; Hazards; Probability Theory; Spacecraft Propulsion

19920013349 Rockwell International Corp., Rocketdyne Div., Canoga Park, CA, USA

Orbit transfer rocket engine technology program: Advanced engine study *Final Report*

Erickson, C. M., Rockwell International Corp., USA; Feb 28, 1992; 84p; In English

Contract(s)/Grant(s): NAS3-23773; RTOP 506-42-21

Report No.(s): NASA-CR-187215; NAS 1.26:187215; RI/RD-90-180; AD-A247458; Avail: CASI; A05, Hardcopy; A01, Microfiche

In Task D.6 of the Advanced Engine Study, three primary subtasks were accomplished: (1) design of parametric data; (2) engine requirement variation studies; and (3) vehicle study/engine study coordination. Parametric data were generated for vacuum thrusts ranging from 7500 lbf to 50,000 lbf, nozzle expansion ratios from 600 to 1200, and engine mixture ratios from 5:1 to 7:1. Failure Modes and Effects Analysis (FMEA) was used as a departure point for these parametric analyses. These data are intended

to assist in definition and trade studies. In the Engine Requirements Variation Studies, the individual effects of increasing the throttling ratio from 10:1 to 20:1 and requiring the engine to operate at a maximum mixture ratio of 12:1 were determined. Off design engine balances were generated at these extreme conditions and individual component operating requirements analyzed in detail. Potential problems were identified and possible solutions generated. In the Vehicle Study/Engine Study coordination subtask, vehicle contractor support was provided as needed, addressing a variety of issues uncovered during vehicle trade studies. This support was primarily provided during Technical Interchange Meetings (TIM) in which Space Exploration Initiative (SEI) studies were addressed.

CASI

Orbit Transfer Vehicles; Rocket Engines; Rocket Nozzles; Space Exploration; Throttling; Thrust; Vacuum

19930017833 NASA Lewis Research Center, Cleveland, OH, USA

Reliability studies of integrated modular engine system designs

Hardy, Terry L., NASA Lewis Research Center, USA; Rapp, Douglas C., Sverdrup Technology, Inc., USA; Jun 1, 1993; 19p; In English; 29th; Joint Propulsion Conference and Exhibit, 28-30 Jun. 1992, Monterey, CA, USA; Sponsored by AIAA

Contract(s)/Grant(s): RTOP 468-02-11

Report No.(s): NASA-TM-106178; E-7774; NAS 1.15:106178; AIAA PAPER 93-1886; Avail: CASI; A03, Hardcopy; A01, Microfiche

A study was performed to evaluate the reliability of Integrated Modular Engine (IME) concepts. Comparisons were made between networked IME systems and non-networked discrete systems using expander cycle configurations. Both redundant and non-redundant systems were analyzed. Binomial approximation and Markov analysis techniques were employed to evaluate total system reliability. In addition, Failure Modes and Effects Analyses (FMEA), Preliminary Hazard Analyses (PHA), and Fault Tree Analysis (FTA) were performed to allow detailed evaluation of the IME concept. A discussion of these system reliability concepts is also presented.

Author

Engine Design; Failure Analysis; Failure Modes; Fault Trees; Modularity; Propulsion System Configurations; Reliability Analysis; Rocket Engine Design

19930065762 NASA Lewis Research Center, Cleveland, OH, USA

Reliability studies of Integrated Modular Engine system designs

Hardy, Terry L., NASA Lewis Research Center, USA; Rapp, Douglas C., Sverdrup Technology, Inc., USA; Jun 1, 1993, pp. 18 p.; In English; 29th; AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, June 28-30, 1993, Monterey, CA, USA; Sponsored by AIAA; Previously announced in STAR as N93-27022

Report No.(s): AIAA PAPER 93-1886; Copyright; Avail: Issuing Activity

A study was performed to evaluate the reliability of Integrated Modular Engine (IME) concepts. Comparisons were made between networked IME systems and non-networked discrete systems using expander cycle configurations. Both redundant and non-redundant systems were analyzed. Binomial approximation and Markov analysis techniques were employed to evaluate total system reliability. In addition, Failure Modes and Effects Analyses (FMEA), Preliminary Hazard Analyses (PHA), and Fault Tree Analysis (FTA) were performed to allow detailed evaluation of the IME concept. A discussion of these system reliability concepts is also presented.

Engine Design; Failure Analysis; Failure Modes; Fault Trees; Modularity; Propulsion System Configurations; Reliability Analysis; Rocket Engine Design

19960009512 Ishikawajima-Harima Heavy Industries Co. Ltd., Tokyo, Japan

Study of the HOPE propulsion system, part 4-B *HOPE suishinkei no sekkei kento, sono 4 no i*

Mar 31, 1994; 46p; In Japanese

Report No.(s): NASDA-CNT-940056-PT-4-B; Avail: CASI; A03, Hardcopy; A01, Microfiche

In order to obtain requisite technical data on the propulsion systems for orbit injection, orbit change and attitude control of HOPE (H-2 Orbiting Plane), several items were investigated in FY 1994. On the propulsion system design considerations, system for reliability improvement, failure mode in each phase and countermeasures and countermeasures for effluence of propellant as investigation of system constitution are described. On Orbit Maneuvering System (OMS) engine conceptual design and subscale OMS engine design, its requested specifications and design policy are presented. Confirmation tests were performed to extend service life of this subscale engine by coupling film cooling system with regenerative cooling system. Engine test, test history, and combustion test results of Ni/Nb combustion chamber are also presented. Data evaluations for service life, thermal characteristics, characteristic exhaust velocity, thrust coefficient, specific thrust, and performance are described. Cutting

inspection data of Ni combustion chamber were obtained on residual stress and aspect of cooling groove. Furthermore, the policy, tasks and schedule of development are described.

NASDA

Failure Analysis; Failure Modes; Hope Aerospace Plane; Life (Durability); Liquid Propellant Rocket Engines; Mechanical Properties; Propulsion System Configurations; Rocket Engine Design

19980071382

Study of synthetic analysis on design reliability of a liquid rocket engine

Kuang, Wuyue, Shaanxi Engine Design Inst., China; Tan, Songlin, Shaanxi Engine Design Inst., China; Journal of Propulsion Technology; Oct. 1997; ISSN 1001-4055; Volume 18, no. 5, pp. 9-12; In Chinese; Copyright; Avail: Aeroplus Dispatch

A synthetic analysis on the design reliability of a liquid rocket engine is presented. A rigorous yet practicable approach for evaluating engine reliability during the conceptual study phase is put forward. The approach uses the proven reliability methods of reliability modeling analysis, Failure Modes and Effects Analysis (FMEA), failure data analysis, and Fault Tree Analysis (FTA) to estimate the probability of mission success at the vehicle level for different engine designs. An example is provided in which the approach is used to evaluate an engine design concept.

Author (AIAA)

Liquid Propellant Rocket Engines; Rocket Engine Design; Reliability Analysis; Engine Failure; Fault Trees

19980089456

Failure mode and analysis for liquid propellant rocket engines

Yin, Qian, Shaanxi Engine Design Inst., China; Zhang, Jinrong, Shaanxi Engine Design Inst., China; Journal of Propulsion Technology; Feb. 1997; ISSN 1001-4055; Volume 18, no. 1, pp. 22-25; In Chinese; Copyright; Avail: AIAA Dispatch

Some failure modes that frequently occur in an engine are presented based on the development history of four turbopump-fed rocket engines. Failure occurrence and spread are described, and the causes and consequences of failure are preliminarily analyzed. Failure modes of turbopump and pipeline are primarily discussed. Some typical examples of pipeline damage occurring in engine hot-firing tests are given, and failure modes of valve and chamber and cable and flexible hose assembly are introduced. Some suggestions are put forward for new engine design and failure detection. Finally, it is pointed out that fault detection systems for manned flights are necessary.

Author (AIAA)

Failure Modes; Failure Analysis; Liquid Propellant Rocket Engines

19980089470

A study on the fault effects analysis of an attitude control engine

Xiao, Mingjie, Shaanxi Engine Design Inst., China; Journal of Propulsion Technology; Feb. 1997; ISSN 1001-4055; Volume 18, no. 1, pp. 79-83; In Chinese; Copyright; Avail: AIAA Dispatch

Considering some faults which had occurred during engine tests or would occur in the future, fault models of a constant pressure feed bipropellant attitude control engine system have been derived. The gradient method was used to solve the models. Several typical faults were simulated, and the effects of these faults were analyzed. The modes of these faults were determined with some selected parameters. Finally, the key parameters which are used to isolate and detect different faults are established.

Author (AIAA)

Failure Analysis; Attitude Control; Rocket Engines; Failure Modes

19980116257

Failure mode analysis of a spacecraft power system

Lee, Jae R., Martin Marietta Astro Space, USA; 1995, pp. 165-170; In English; Copyright; Avail: Aeroplus Dispatch

For a spacecraft power system's dynamic analyses, dc/dc converters are usually modeled with a linearized model using the state space averaging technique. The linearized model can be used for small-signal ac and transient analyses. However, since the linearized model has limitations in its accuracies, certain types of transient analyses, including a failure mode, must be performed by using a more accurate cycle-by-cycle model. In this paper, a failure mode analysis is presented with a small-signal analysis and corresponding transient simulations.

Author (AIAA)

Failure Modes; Failure Analysis; Spacecraft Power Supplies; Voltage Converters (DC to DC)

19980120576

FMEA/CIL implementation for the Space Shuttle new turbopumps

Littlefield, Milton L., Pratt & Whitney, USA; 1996, pp. 48-52; In English; Copyright; Avail: Aeroplus Dispatch

To satisfy a reliability requirement which necessitated the implementation of the Space Shuttle High Pressure Oxidizer Turbopump (HPOTP) Failure Mode Effects Analysis (FMEA) and Critical Items List (CIL), Pratt & Whitney (P&W) developed a plan that emphasized the utilization of existing systems and the standardization of subcontractor reporting documentation. Prior to acceptance testing of the first flight HPOTP, an audit of the quality assurance records for all CIL required inspections was performed to determine if the inspections had been made and accepted by quality assurance. 99.9 percent of the CIL inspections were verified as being successfully completed, far exceeding the 90 percent NASA verification requirement. Essential to the success of CIL implementation were the analytical procedures used to identify and ensure the test/inspectability of the inspections, testing, and process controls (CIL characteristics) performed to minimize the probability of critical part failures.

Author (AIAA)

Failure Modes; Failure Analysis; Turbine Pumps; Space Shuttles; Spacecraft Equipment; Reliability

19980130437

The role of analysis and testing in the service life assessment of ion engines

Polk, J. E., JPL, USA; Moore, N. R., JPL, USA; Brophy, J. R., JPL, USA; Ebbeler, D. H., JPL, USA; 1996, pp. 698-713; In English Report No.(s): IEPC-95-228; Copyright; Avail: Aeroplus Dispatch

Experience from tests and flights and engineering analysis represent the two sources of information on which to base conclusions on the reliability or failure risk of aerospace flight systems. It is rarely feasible to establish high reliability at high confidence by testing aerospace flight systems or components. The limitations of testing in evaluating failure risk are discussed, and an alternate statistical approach which relies on both test experience and analysis to quantitatively assess reliability is outlined. The implementation of this methodology in the service life assessment of ion thrusters is discussed, and examples of failure modes being addressed in the NASA Solax Electric Propulsion Technology Application Readiness (NSTAR) program are given.

Author (AIAA)

Service Life; Ion Engines; Failure Modes; Failure Analysis; Erosion

19980134248

Investigation of new short circuit modes on solar arrays

Soubeyran, A., Matra Marconi Space, France; Matucci, A., Proel Technologie, Italy; Levy, L., CERT, France; Mandeville, J. C., CERT, France; Gerlach, L., ESTEC, Netherlands; Stevens, J., TRW, Inc., USA; 1995, pp. 567-571; In English; Copyright; Avail: Aeroplus Dispatch

Within the framework of a two-year study with ESA, we investigated new ways of understanding Kapton shorting both from the theoretical and experimental point of view: discharge triggered by micrometeoroid impact; Kapton aging by internal partial discharges; and discharge coupling with dynamic electrical system interaction involving long-line inductance and inducing a high electrical stress on the Kapton layer. Many conceptual ideas were justified by experimental results. The final coupling experiments did not confirm the resulting shorting risk through the Kapton layer.

Author (AIAA)

Solar Arrays; Short Circuits; Kapton (Trademark); Failure Analysis; Failure Modes

19980191292

Preliminary failure modes, effects, and criticality analysis of the NiMH cell for aerospace batteries

Klein, Glenn C., Gates Aerospace Batteries, USA; 1993, pp. 1.207-1.217; In English; Copyright; Avail: Aeroplus Dispatch

The Preliminary Failure Modes, Effects, and Criticality Analysis (FMECA), which makes it possible to analyze both the robustness and reliability of basic cell designs and various design iterations for aerospace batteries, is presented. A generic FMECA for NiMH aerospace cells is given in tabular form. For sophisticated technology such as the NiMH cell for aerospace applications, the FMECA must be used to validate and qualify the fabrication, test, and inspection process.

AIAA

Failure Modes; Aerospace Engineering; Reliability Analysis; Nickel Hydrogen Batteries; Failure Analysis

19980210866 Hernandez Engineering, Inc., Huntsville, AL USA

Space Shuttle Main Engine Quantitative Risk Assessment: Illustrating Modeling of a Complex System with a New QRA Software Package

Smart, Christian, Hernandez Engineering, Inc., USA; 1998; 6p; In English; PSAM IV, 13-18 sEP. 1998, New York, NY, USA

Report No.(s): NASA/TM-1998-208244; NAS 1.15:208244; No Copyright; Avail: CASI; A02, Hardcopy; A01, Microfiche

During 1997, a team from Hernandez Engineering, MSFC, Rocketdyne, Thiokol, Pratt & Whitney, and USBI completed the first phase of a two year Quantitative Risk Assessment (QRA) of the Space Shuttle. The models for the Shuttle systems were entered and analyzed by a new QRA software package. This system, termed the Quantitative Risk Assessment System (QRAS), was designed by NASA and programmed by the University of Maryland. The software is a groundbreaking PC-based risk assessment package that allows the user to model complex systems in a hierarchical fashion. Features of the software include the ability to easily select quantifications of failure modes, draw Event Sequence Diagrams (ESDs) interactively, perform uncertainty and sensitivity analysis, and document the modeling. This paper illustrates both the approach used in modeling and the particular features of the software package. The software is general and can be used in a QRA of any complex engineered system. The author is the project lead for the modeling of the Space Shuttle Main Engines (SSMEs), and this paper focuses on the modeling completed for the SSMEs during 1997. In particular, the groundrules for the study, the databases used, the way in which ESDs were used to model catastrophic failure of the SSMEs, the methods used to quantify the failure rates, and how QRAS was used in the modeling effort are discussed. Groundrules were necessary to limit the scope of such a complex study, especially with regard to a liquid rocket engine such as the SSME, which can be shut down after ignition either on the pad or in flight. The SSME was divided into its constituent components and subsystems. These were ranked on the basis of the possibility of being upgraded and risk of catastrophic failure. Once this was done the Shuttle program Hazard Analysis and Failure Modes and Effects Analysis (FMEA) were used to create a list of potential failure modes to be modeled. The groundrules and other criteria were used to screen out the many failure modes that did not contribute significantly to the catastrophic risk. The Hazard Analysis and FMEA for the SSME were also used to build ESDs that show the chain of events leading from the failure mode occurrence to one of the following end states: catastrophic failure, engine shutdown, or successful operation (successful with respect to the failure mode under consideration).

Derived from text

Space Shuttle Main Engine; Applications Programs (Computers); Assessments; Failure Analysis

24

COMPOSITE MATERIALS

Includes physical, chemical, and mechanical properties of laminates and other composite materials.

19830025698 Illinois Inst. of Tech., Chicago, IL, USA

Experimental methods for identifying failure mechanisms

Daniel, I. M., Illinois Inst. of Tech., USA; NASA. Langley Research Center Failure Anal. and Mech. of Failure of Fibrous Composite Struct.; Aug 1, 1983, pp. p 313-341; In English; See also N83-33957 22-24; A03

Experimental methods for identifying failure mechanisms in fibrous composites are studied. Methods to identify failure in composite materials includes interferometry, holography, fractography and ultrasonics.

B.W.

Coatings; Composite Structures; Crack Propagation; Failure Analysis; Failure Modes; Fibers; Laminates

19830035886

An analysis of impact failure modes for fiber-reinforced composite laminates by using fault tree

Fukuda, T.; Fujii, T., Osaka City University, Japan; Miki, M., Kanazawa Institute of Technology, Japan; Nagamori, M., Osaka Municipal Technical Research Institute, Japan; Jan 1, 1982; 6p; In English; 25th; Japan Congress on Materials Research, October 1981, Tokyo, Japan; See also A83-17086 05-23; Copyright; Avail: Issuing Activity

No abstract.

Charpy Impact Test; Failure Analysis; Failure Modes; Fault Trees; Fiber Composites; Laminates

19840025454 Southwest Research Inst., San Antonio, TX, USA

Evaluation of the effects of stress state and interfacial properties on the behavior of advanced metal matrix composites
Final Report

Leverant, G. R., Southwest Research Inst., USA; Hack, J. E., Southwest Research Inst., USA; Page, R. A., Southwest Research Inst., USA; Jul 1, 1984; 9p; In English

Contract(s)/Grant(s): DAAG29-81-K-0049

Report No.(s): AD-A143911; ARO-17207.4-MS; Avail: CASI; A02, Hardcopy; A01, Microfiche

The effects of fiber fraction, fiber orientation and matrix alloy additions on tensile and fatigue behavior were studied in commercially pure magnesium and ZE41A (Mg-4.25Zn-0.5Zr-1.25RE) that were both reinforced with FP alumina fibers. In general, axial properties were not. Off-axis loading resulted in substantial reductions in tensile and fatigue strength in the commercially pure matrix material. Although failure in tensile overload occurred along the weak fiber/matrix interface in off-axis specimens, subcritical fatigue cracks propagated parallel to the fiber direction but through the matrix. The fractographic appearance of these cracks is similar to cyclic cleavage along slip planes. The critical stress intensity for unstable fracture of off-axis material was controlled by a combination of the normal and shear stress components acting on the fiber/matrix interface. The alloying conditions in ZE41A resulted in a slight decrease in axial properties accompanied by a significant improvement in off-axis behavior. These differences were found to be a result of improved matrix and interface strengths and a decrease in fiber strength. The reaction zone product in both materials was determined to be MgO.

DTIC

Crack Propagation; Failure Analysis; Failure Modes; Fatigue (Materials); Fiber Orientation; Fracture Mechanics; Magnesium Alloys; Metal Matrix Composites; Microstructure; Reinforcing Fibers; Stress Distribution; Tensile Strength

19840042102

A residual strength degradation model for competing failure modes

Whitney, J. M., USAF, Materials Laboratory, Wright-Patterson AFB, USA; Jan 1, 1983; 21p; In English; See also A84-24876 10-24; Copyright; Avail: Issuing Activity

In the present residual strength degradation model, tensile and compressive strength degradation are taken to be competing failure modes. Static strength distributions are assumed to follow a two-parameter lognormal distribution, while the residual strength degradation equations are based on a three-parameter power law model. A procedure is given for the determination of model parameters, and comparisons are made between theoretical and experimental results for constant amplitude tension-tension and tension-compression fatigue data. Both the residual tensile and the residual compressive data obtained under these two load histories are considered.

AIAA

Compressive Strength; Failure Analysis; Failure Modes; Fiber Composites; Tensile Strength

19840057753

Failure of composite laminates containing pin loaded holes Method of solution

Chang, F.-K.; Scott, R. A., Michigan, University, USA; Springer, G. S., Stanford University, USA; Journal of Composite Materials; May 1, 1984; ISSN 0021-9983; 18, pp. 255-278; In English; USAF-supported research; Copyright; Avail: Issuing Activity

The failure strength and mode of fiber-reinforced composite laminates with one or two pin-loaded holes are predicted by a method in which the stress distribution is calculated by means of FEM, and failure characteristics are obtained by a combination of a novel failure hypothesis together with the Yamada and Sun (1978) failure criterion. A computer code has been developed which can be used to calculate the maximum load and failure mode of laminates having different ply orientations, material properties, and geometries. Model results have been compared with test results for T300/1034-C laminates, and good agreement is noted.

AIAA

Failure Analysis; Failure Modes; Fiber Composites; Hole Distribution (Mechanics); Holes (Mechanics); Laminates; Pins

19840057755

The effect of laminate configuration on characteristic lengths and rail shear strength

Chang, F.-K.; Scott, R. A., Michigan, University, USA; Springer, G. S., Stanford University, USA; Journal of Composite Materials; May 1, 1984; ISSN 0021-9983; 18, pp. 290-296; In English; USAF-supported research; Copyright; Avail: Issuing Activity

Tests were performed measuring the characteristic lengths in tension and in compression and the rail shear strength of Fiberite T300/1034-C graphite epoxy composites. The results show the effects of geometry on the characteristic lengths. The results also indicate the variability of rail shear strength with the volume fraction of zero degree plies in the laminate.

AIAA

Failure Analysis; Failure Modes; Hole Geometry (Mechanics); Laminates; Load Tests; Shear Strength

19860012149 California Univ., School of Engineering and Applied Science., Los Angeles, CA, USA

Stress-strain behavior and failure of uniaxial composites in combined compression and shear - 1 *Interim Technical Report*

Batdorf, S. B., California Univ., USA; Ko, R. W. C., California Univ., USA; Jul 1, 1985; 19p; In English

Contract(s)/Grant(s): N00014-77-C-0505

Report No.(s): AD-A161772; UCLA-ENG-85-25; Avail: CASI; A03, Hardcopy; A01, Microfiche

The effects of increasing fiber tilt with increasing load in uniaxial composites, culminating in kink band formation is considered. The fibers themselves are assumed to remain elastic. Nonlinearities result from changing fiber tilt and yielding of the matrix. Compressive stress-strain relations and failure are treated from a unified viewpoint. Comparisons are made between theory and experiment.

DTIC

Carbon-Carbon Composites; Composite Materials; Elastic Deformation; Failure Analysis; Failure Modes; Fiber Composites; Reinforcing Fibers; Stress-Strain Relationships

19860065462

Detection of failure progression in cross-ply graphite/epoxy through emission

Awerbuch, J.; Eckles, W. F., Drexel University, USA; Jan 1, 1986; 10p; In English; See also A86-50076

Contract(s)/Grant(s): F33615-84-C-3204; Copyright; Avail: Issuing Activity

This paper presents results and analyses of acoustic emission (AE) monitored during quasi-static loading in a variety of cross-ply graphite/epoxy laminates having different stacking sequences and containing different ratios of ply thickness. The purpose of the analysis was to determine the correlation between the AE results and the actual failure processes. Results indicate that stacking sequence strongly affects the event intensities; e.g., event amplitude, energy, duration, rise-time, and counts. Also, stacking sequence has a significant effect on damage initiation and accumulation and on the failure process as detected through AE. A significant amount of emission is generated by friction among newly created fracture surfaces, in some cases exceeding that generated by new damage. The friction-generated emission can be discriminated using the AE source-intensity-threshold values. Matrix-dominated failures and fiber breakage result in middle-range and high-range AE source intensities, respectively. Based on these results damage curves were constructed which distinguish among the emissions generated by friction, by primarily matrix-dominated failures, and by fiber breakage.

AIAA

Acoustic Emission; Failure Analysis; Failure Modes; Graphite-Epoxy Composites; Laminates; Ply Orientation

19890045758

Expansion of fractographic data base for carbon fiber reinforced plastics (CFRP)

Yamashita, M. M.; Hua, C. T., Boeing Co., USA; Stumpff, P., USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, USA; Jan 1, 1988; 9p; In English; ISTFA 1988, Oct. 31-Nov. 4, 1988, Los Angeles, CA, USA; See also A89-33126 13-23

Contract(s)/Grant(s): F33615-86-C-5071; Copyright; Avail: Issuing Activity

Modifications in the fracture topographical features of composite parts due to factors such as manufacturing anomalies and in-service and post-failure environmental conditions are investigated. The material considered was a 177C cured epoxy-based resin with AS4 carbon fiber. It is found that low resin content had a more significant effect than high resin content in modifying the fracture features under both mode I and mode II interlaminar fracture and mode I translaminar fracture conditions.

AIAA

Aircraft Construction Materials; Carbon Fiber Reinforced Plastics; Environmental Tests; Failure Analysis; Failure Modes; Fractography

19890045762

Fractography of graphite/bismaleimide and graphite/PEEK composites

Saliba, Susan S., Dayton, University, USA; Jan 1, 1988; 10p; In English; ISTFA 1988, Oct. 31-Nov. 4, 1988, Los Angeles, CA, USA; See also A89-33126 13-23; Copyright; Avail: Issuing Activity

Results are presented for the conditioning, mechanical testing, and fractographic evaluation of graphite/bismaleimide (GR/BM) and GR/PEEK samples. No significant effect was found in the mechanical properties of either material due to humidity aging. As with the GR/BM material, the most fiber pull-out for the GR/PEEK material was noted on the fracture surface of the 0 deg tension specimens.

AIAA

Carbon Fiber Reinforced Plastics; Failure Analysis; Failure Modes; Fractography; Load Tests; Polymer Matrix Composites

19900005822 Virginia Univ., Charlottesville, VA, USA

Fatigue properties of SiC/Al composites

Gomez, Jose Pantaleon, III, Virginia Univ., USA; Jan 1, 1988; 152p; In English; Avail: Univ. Microfilms Order No. DA8913014, Unavail. Microfiche

Silicon carbide monofilaments, produced by chemical vapor deposition, have several different classifications depending on the surface treatment imparted to the fiber at the final stage of production. The newest of these fibers, designated SCS-8, is produced specifically for aluminum matrix composites in an attempt to improve transverse mechanical properties over the other types. The focus is on the response of SCS-8/6061 Al alloy composites to cyclic loading. Laminates with fibers oriented in the 0, 90, and + or - 45 degree direction were used. Particular emphasis was on elastic modulus changes due to fatigue. Modulus changes could be observed in as few as ten cycles, depending upon stress and laminate orientation. Unnotched specimens were axially loaded in tension-tension ($R = 0.1$) mode with a sinusoidal waveform at a frequency of 10 Hz. Periodically, cycling was stopped and the specimen elastic modulus determined. Modulus values at N number of cycles, $E(\text{sub } N)$, normalized with respect to virgin modulus, $E(\text{sub } 0)$, were then plotted versus log number of cycles. Conventional fatigue induced fracture behavior was also obtained and reported in the familiar S-N format. Fractographic observation indicates several failure modes: fiber splitting, fiber/matrix debonding, matrix shear failure, interply delaminating, and fiber fracture. Axial tension-tension high cycle fatigue behavior is controlled by the matrix. Low cycle fatigue and static behavior is characterized by progressive failure of the SiC fiber. Modulus change is the result of crack propagation along the fiber-matrix interface.

Dissert. Abstr.

Aluminum Alloys; Failure Analysis; Failure Modes; Mechanical Properties; Metal Matrix Composites; Silicon Carbides

19900010835 NASA Lewis Research Center, Cleveland, OH, USA

Fundamental aspects of and failure modes in high-temperature composites

Chamis, Christos C., NASA Lewis Research Center, USA; Ginty, Carol A., NASA Lewis Research Center, USA; Jan 1, 1990; 16p; In English; 35th; International SAMPE Symposium and Exhibition, 2-5 Apr. 1990, Anaheim, CA, USA

Contract(s)/Grant(s): RTOP 510-01-0A

Report No.(s): NASA-TM-102558; E-5378; NAS 1.15:102558; Avail: CASI; A03, Hardcopy; A01, Microfiche

Fundamental aspects of and attendant failure mechanisms for high temperature composites are summarized. These include: (1) in-situ matrix behavior; (2) load transfer; (3) limits on matrix ductility to survive a given number of cyclic loadings; (4) fundamental parameters which govern thermal stresses; (5) vibration stresses; and (6) impact resistance. The resulting guidelines are presented in terms of simple equations which are suitable for the preliminary assessment of the merits of a particular high temperature composite in a specific application.

CASI

Ceramic Matrix Composites; Failure Analysis; Failure Modes; High Temperature; Metal Matrix Composites; Temperature Effects

19900011818 Nebraska Univ., Lincoln, NE, USA

Compressive behavior of laminated composite structures

Ko, Siu-Ping, Nebraska Univ., USA; Jan 1, 1989; 146p; In English; Avail: Univ. Microfilms Order No. DA9004684, Unavail. Microfiche

Physical testing of laminated structures has indicated that the compressive strength is often considerably lower than that predicted by analytical methods. Poor testing techniques and poorly constructed materials seem to be possible reasons for the premature failure. However, since many of the failures are characterized by delamination of the structures, the cause of the failure may be due to local buckling of the composite plies. A ply buckling model is studied to assist in the understanding of the failure mechanisms. In order to find the failure envelope, inplane fracture and overall buckling are assumed as the failure modes of these structures. The classical theory of elasticity for thin shells, including transverse shear deformation, is used in the derivation. Then the relations between the predicted failure stresses and laminate orientations can be obtained. A simple optimum design procedure for laminate orientation and hoop/helical ply thickness ratio is proposed by using the previous two failure theories. The optimal point may be defined as the highest intersection of the various failure criteria. Results are presented in the form of a parametric study for three stacking sequences. Finally, the comparison of the failure stresses between the laminate with and without an inside hoop layer is discussed.

Dissert. Abstr.

Buckling; Composite Structures; Compressive Strength; Delaminating; Failure Analysis; Failure Modes; Laminates; Thin Walled Shells

19900012504 Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, USA

Strength in notched and impact-damaged laminates

El-Zein, Mohamad Samih, Virginia Polytechnic Inst. and State Univ., USA; Jan 1, 1989; 84p; In English; Avail: Univ. Microfilms Order No. DA9003589, Unavail. Microfiche

The strength of notched and impact damaged laminates was studied. The solution for a plate containing an elliptic opening and inclusion was used as given by Lekhnitskii. The solution for the infinite plate, combined with laminate analysis to determine the ply stresses, and the average stress criterion proposed by Whitney and Nuismer were used to predict the notched strength. However, unlike Whitney and Nuismer, the average stress criterion was used at the ply level. The strength of off-axis unidirectional laminates was predicted by using a matrix oriented failure criterion applied at a critical point on the boundary of the hole. A good agreement between the experimental and predicted data was obtained. On the other hand, an attempt made to predict the notched strength of angle-ply laminates was not as successful. This is believed to be due to the different failure modes existing among different (+/- theta) sub s laminates. The controversy on whether the characteristic dimension is a material or geometric property, together with the belief that the physics of fracture of composites is better represented at the ply level, was the motivation to seek an invariant equation which describes the dependence of the characteristic dimension, $D(\text{sub } o)$. A quantitative approach to determine the characteristic dimension in the average stress criterion was proposed. A good agreement between experimental and predicted data was found. It was also found that contrary to prior claims, the value of $D(\text{sub } o)$ does not depend on the diameter of the hole, when used at the ply level. The tensile strength after impact (TSAI) was investigated. An approach based on modeling the delaminated area as an elliptic inclusion was used.

Dissert. Abstr.

Failure Analysis; Failure Modes; Laminates; Mathematical Models; Notch Tests; Stress Analysis; Tensile Strength

19900015733 Wichita State Univ., Dept. of Aerospace Engineering., Wichita, KS, USA

Development of a finite element based delamination analysis for laminates subject to extension, bending, and torsion
Abstract Only

Hooper, Steven J., Wichita State Univ., USA; Old Dominion Univ., NASA/American Society for Engineering Educ; Sep 1, 1989, pp. Old Dominion Univ., ; In English; Avail: Issuing Activity

Delamination is a common failure mode of laminated composite materials. This type of failure frequently occurs at the free edges of laminates where singular interlaminar stresses are developed due to the difference in Poisson's ratios between adjacent plies. Typically the delaminations develop between 90 degree plies and adjacent angle plies. Edge delamination has been studied by several investigators using a variety of techniques. Recently, Chan and Ochoa applied the quasi-three-dimensional finite element model to the analysis of a laminate subject to bending, extension, and torsion. This problem is of particular significance relative to the structural integrity of composite helicopter rotors. The task undertaken was to incorporate Chan and Ochoa's formulation into a Raju Q3DG program. The resulting program is capable of modeling extension, bending, and torsional mechanical loadings as well as thermal and hygroscopic loadings. The addition of the torsional and bending loading capability will provide the capability to perform a delamination analysis of a general unsymmetric laminate containing four cracks, each of a different length. The solutions obtained using this program are evaluated by comparing them with solutions from a full three-dimensional finite element solution. This comparison facilitates the assessment of three dimensional affects such as the warping constraint imposed by the load frame grips. It also facilitates the evaluation of the external load representation employed in the Q3D formulation. Finally, strain energy release rates computed from the three-dimensional results are compared with those predicted using the quasi-three-dimensional formulation.

CASI

Bending; Delaminating; Failure Analysis; Failure Modes; Finite Element Method; Laminates; Mathematical Models; Structural Failure; Three Dimensional Models; Torsion

19900016770 National Aerospace Lab., Tokyo, Japan

Study on failure modes of boron fiber reinforced aluminum composite materials by AE method, part 2

Sofue, Yasushi, National Aerospace Lab., Japan; Ogawa, Akinori, National Aerospace Lab., Japan; Jun 1, 1989; ISSN 0389-4010; 13p; In Japanese

Report No.(s): DE90-505522; NAL-TR-1030-PT-2; Avail: CASI; A03, Hardcopy; A01, Microfiche

The failure modes of boron fiber reinforced aluminum composite materials were examined by the power spectrum analysis of AE waves. The 6061 aluminum alloy was used as a matrix, and four types of specimens such as a unidirectionally fiber reinforced composite material were prepared for tensile tests. In boron fiber breakage, power spectra indicated high peaks in the low frequency range from 100 to 200 kHz, and in fiber breakage of composite materials, AE waves continued occasionally for 3.84 ms or more due to the friction between a matrix and fibers. In 6061 aluminum alloy, AE waves were different between tensile

and shear fracture, showing a short damping time in tensile fracture and a long time in shear, independently of small amplitudes in both fractures. The power spectra of the alloy indicated high peaks in the high frequency range from 400 to 900 kHz, and AE waves continued for only 64 microsec or less extremely short compared with those in fiber breakage.

DOE

Acoustic Emission; Boron Fibers; Failure Analysis; Failure Modes; Fiber Composites

19900044396 NASA Langley Research Center, Hampton, VA, USA

Metal matrix composites: Testing, analysis, and failure modes; Proceedings of the Symposium, Sparks, NV, Apr. 25, 26, 1988

Johnson, W. S., editor, NASA Langley Research Center, USA; Jan 1, 1989; 294p; In English; Symposium on Metal Matrix Composites: Testing, Analysis, and Failure Modes, Apr. 25-26, 1988, Sparks, NV, USA; Sponsored by ASTM

Report No.(s): ASTM STP-1032; Copyright; Avail: Issuing Activity

The present conference discusses the tension and compression testing of MMCs, the measurement of advanced composites' thermal expansion, plasticity theory for fiber-reinforced composites, a deformation analysis of boron/aluminum specimens by moire interferometry, strength prediction methods for MMCs, and the analysis of notched MMCs under tensile loading. Also discussed are techniques for the mechanical and thermal testing of Ti3Al/SCS-6 MMCs, damage initiation and growth in fiber-reinforced MMCs, the shear testing of MMCs, the crack growth and fracture of continuous fiber-reinforced MMCs in view of analytical and experimental results, and MMC fiber-matrix interface failures.

AIAA

Conferences; Failure Analysis; Failure Modes; Metal Matrix Composites

19900063040 NASA Lewis Research Center, Cleveland, OH, USA

Fundamental aspects and failure modes in high-temperature composites

Chamis, C. C., NASA Lewis Research Center, USA; Ginty, C. A., NASA Lewis Research Center, USA; Jan 1, 1990; 14p; In English; 35th; International SAMPE Symposium and Exhibition, Apr. 2-5, 1990, Anaheim, CA, USA; See also A90-50056; Copyright; Avail: Issuing Activity

Fundamental aspects and attendant failure mechanisms for high-temperature composites are summarized. These include in situ matrix behavior, load transfer, limits on matrix ductility to survive a given number of cyclic loadings, fundamental parameters which govern thermal stresses, vibration stresses and impact resistance, as well as their attendant failure mechanisms and failure sequences. The resulting guidelines are presented in terms of simple equations which are suitable for the preliminary assessment of the merits of a particular high-temperature composite in a specific application.

AIAA

Failure Analysis; Failure Modes; Fiber Composites; Metal Matrix Composites; Refractory Materials

19910010923 Air Force Inst. of Tech., Wright-Patterson AFB, OH, USA

Investigation of damage mechanisms in a cross-ply metal matrix composite under thermo-mechanical loading

Schubbe, Joel J., Air Force Inst. of Tech., USA; Dec 1, 1990; 163p; In English

Report No.(s): AD-A230544; AFIT/GAE/ENY/90D-26; Avail: CASI; A08, Hardcopy; A02, Microfiche

Metal matrix composites (MMC's) are rapidly becoming strong candidates for high temperature and high stiffness structural applications such as the advanced tactical fighter (ATF). This study systematically investigated the failure modes and associated damage in a cross-ply, (0/90)2s SCS6/Ti-15-3 metal matrix composite under in-phase and out-of-phase thermomechanic fatigue. Initiation and progression of fatigue damage were recorded and correlated to changes in Young's Modulus of the composite material. Experimental results show an internal stabilization of reaction zone size but degradation and separation from constituent materials under extended cyclic thermal loading. Critical to damage were transverse cracks initiating in the 90 degree plies, growing and coalescing from fiber/matrix interfaces internal to the specimen, progressing outward through the 0 degree plies before failure. Maximum mechanical strain at failure was determined to be approximately 0.0075 mm/mm. A correlation was made relating maximum matrix stress to failure life, resulting in a fatigue threshold limit of 280 MPa. An attempt was made to correlate the degradation in Young's Modulus (damage = 1-E/Eo) with the applied life cycles from different TMF tests.

DTIC

Failure Analysis; Failure Modes; Fatigue (Materials); Fatigue Tests; Load Tests; Metal Matrix Composites; Modulus of Elasticity; Thermal Cycling Tests

19910018972 Lawrence Livermore National Lab., Livermore, CA, USA

On the finite-strain-invariant failure criterion for composites

Feng, W. W., Lawrence Livermore National Lab., USA; Groves, S. E., Lawrence Livermore National Lab., USA; Feb 1, 1991; 9p; In English; 8th; International Conference on Composite Materials, 15-19 Jul. 1991, Honolulu

Contract(s)/Grant(s): W-7405-ENG-48

Report No.(s): DE91-011924; UCRL-JC-106555; CONF-910731-3; Avail: CASI; A02, Hardcopy; A01, Microfiche

The finite-strain-invariant failure criterion developed by Feng is being evaluated with the experimental data for a boron/epoxy, symmetrically balanced, angle-ply laminate. The results indicate that the failure-criterion prediction agrees with the experimental data and that the failure criterion also predicts the matrix-dominated or fiber-dominated modes of failure. Two special isotropic cases in infinitesimal strain theory are obtained. The failure criteria for these special cases preserve the mathematical forms of both the generalized Von Mises yield criterion and the Von Mises yield criterion in plasticity.

DOE

Boron-Epoxy Composites; Failure Analysis; Failure Modes; Finite Element Method; Stress Analysis

19920022803 Northrop Corp., Aircraft Div., Hawthorne, CA, USA

Composite failure analysis handbook. Volume 1: Program review *Final Report, 1 Jan. 1987 - 31 Oct. 1990*

Kar, R. J., Northrop Corp., USA; Feb 1, 1992; 184p; In English

Contract(s)/Grant(s): F33615-87-C-5212

Report No.(s): AD-A250520; WL-TR-91-4032-VOL-1; DOT/FAA/CT-91/23-VOL-1; Avail: CASI; A09, Hardcopy; A02, Microfiche

The objective of this program was to create a comprehensive handbook for use in conducting failure analysis investigations on failed composite structure. This program builds upon previous efforts as documented in the 'Compendium of Post-Failure Analysis Techniques for Composite Materials'. The purpose of creating this handbook was to document the techniques, the fractographic and material property data, and case history studies currently being utilized in the analysis of failed composite structure. The major tasks on this program included: (1) procedural guidelines for field investigation techniques; (2) an expanded fractographic data base for carbon/epoxy materials tested under known conditions; (3) a fractographic data base for resin based composite materials other than carbon/epoxy; (4) fractographic documentation of composite material and processing defects; (5) documentation of fracture characteristics in adhesive and mechanical joint failures; (6) compilation of material property data for composite materials; and (7) documentation of case histories recently conducted on failed composite structure.

DTIC

Case Histories; Composite Materials; Composite Structures; Data Bases; Failure Analysis; Failure Modes; Handbooks; Materials Tests; Shear Properties

19920022804 Northrop Corp., Aircraft Div., Hawthorne, CA, USA

Composite failure analysis handbook. Volume 2: Technical handbook. Part 1: Procedures and techniques *Final Report, 1 Jan. 1987 - 31 Oct. 1990*

Kar, R. J., Northrop Corp., USA; Feb 1, 1992; 266p; In English

Contract(s)/Grant(s): F33615-87-C-5212

Report No.(s): AD-A250521; WL-TR-91-4032-VOL-2-PT-1; DOT/FAA/CT-91-23-VOL-2-PT-1; Avail: CASI; A12, Hardcopy; A03, Microfiche

The objective of this program was to create a comprehensive handbook for use in conducting failure analysis investigations on failed composite structure. This program builds upon previous efforts as documented in the 'Compendium of Post-Failure Analysis Techniques for Composite Materials'. The purpose of creating this handbook was to document the techniques, the fractographic and material property data and case history studies currently being utilized in the analysis of failed composite structure. The major tasks of this program included: (1) procedural guidelines for field investigation techniques; (2) an expanded fractographic data base for carbon/epoxy materials tested under known conditions; (3) a fractographic data base for resin based composite materials other than carbon/epoxy; (4) fractographic documentation of composite material and processing defects; (5) documentation of fracture characteristics in adhesive and mechanical joint failures; (6) compilation of material property data for composite materials; and (7) documentation of case histories recently conducted on failed composite structure.

DTIC

Case Histories; Composite Materials; Composite Structures; Data Bases; Failure Analysis; Failure Modes; Fractography; Handbooks; Materials Tests

19920023790 Dayton Univ., OH, USA

Issues in compression loading of composite structures

Whitney, James M., Dayton Univ., USA; AGARD, The Utilization of Advanced Composites in Military Aircraft; Apr 1, 1992, pp. 5 p; In English; See also N92-33033 23-24; Copyright; Avail: CASI; A01, Hardcopy; A03, Microfiche

Compression loading causes difficulty in development of test methods and failure criteria. Compression testing has produced considerable controversy with a number of different experimental methods being considered. Each method, however, often produces different values of apparent compression strength. The failure mode is the key issue, as each test may produce a different failure mode. In addition, the failure modes often depend on fiber and matrix properties and on laminate geometry. When data is reported, the failure mode is often ignored. In analyzing failure modes, one must consider how relevant the test geometry and load introduction is to the actual application for which the data is being generated. Development of failure criteria also creates difficulty because of the various possible failure modes.

CASI

Composite Structures; Compression Loads; Compression Tests; Compressive Strength; Failure Analysis; Failure Modes; Laminates

19920024750 Messerschmitt-Boelkow-Blohm G.m.b.H., Munich, Germany

Stability failure of sandwich structures

Dreher, G., Eurocopter Hubschrauber G.m.b.H., Munich, Germany, USA; Jan 1, 1992; 16p; In English; 2nd; International Conference Construction, 9-12 Mar. 1992, Gainesville, FL, USA

Report No.(s): MBB-UD-0613-92-PUB; Avail: CASI; A03, Hardcopy; A01, Microfiche

Results of a theoretical and experimental study on different stability failure modes of plane sandwich structures subjected to compressive respectively flexural loading are presented. Depending on geometry and material properties of the structure different stability failure modes occur. In the theoretical studies several calculation methods capable of determining the critical linear buckling load are summarized and verified by FE (Finite Element) analysis. The experimental results are compared with the theoretical predictions (analytical methods and FE analysis). The comparison revealed a reasonably good correlation between theory and experiment.

ESA

Failure Analysis; Failure Modes; Finite Element Method; Sandwich Structures; Structural Stability

19920050137

Characterization of mode I, mode II and mixed mode I + II delamination failure in multidirectional laminates for glass/epoxy

Gong, X. J.; Benzeggagh, M. L.; Laksmi, A.; Roelandt, J. M., Compiegne, Universite, France; Jan 1, 1991; 10p; In English; 8th; International Conference on Composite Materials (ICCM/8), July 15-19, 1991, Honolulu, HI, USA; Sponsored by SAMPE; See also A92-32535; Avail: Issuing Activity

In this paper, mode I (DCB), mode II (ENF) and mixed mode I + II (MMF) delamination processes were described in multidirectional reinforced composite of glass/epoxy. by changing the reinforced angle, and keeping the symmetrical laminate properties, the effects of the laminate coupling coefficients on the critical strain energy release rate were observed. For the mode I dominant interlaminar fracture, the material toughness varied with the laminate coupling curvatures K_y/K_x and K_{xy}/K_x . An empirical criterion could characterize this type of fracture well. But in the case of shearing mode delamination, the mechanisms of the fracture were very different from the peeling mode dominant ones.

AIAA

Delaminating; Epoxy Matrix Composites; Failure Analysis; Failure Modes; Glass Fiber Reinforced Plastics; Laminates

19920075782 Delaware Univ., Center for Composite Materials., Newark, DE, USA

An experimental investigation of AS4/2220-3 graphite epoxy woven fabric composite bolted joints *Final Report*

Wilson, Dale W., Delaware Univ., USA; Pipes, R. Byron, Delaware Univ., USA; Jan 1, 1986; 141p; In English

Contract(s)/Grant(s): NAG1-281

Report No.(s): NASA-CR-187342; NAS 1.26:187342; CCM-86-07; Avail: CASI; A07, Hardcopy, Microfiche

The influence of design parameters on the strength and failure mode behavior of bolted joints in AS4/2220-3 plain weave fabric graphite epoxy laminates has been investigated. The effects of fastener size, laminate thickness, fastener half spacing and fastener torque were experimentally characterized for two stacking sequence configurations of quasi-isotropic laminates. Qualitative characterization of failure mechanisms and joint strength was performed for laminates configured with varying percentages of angle plies. The experimental data was used to assess the effectiveness of a composite bolted joint strength model

based on the application of a quadratic interaction failure criterion on a 'critical distance' plane around the loaded portion of the hole. The strength model was found to work when properly calibrated to data for the material system and range of geometric parameters considered. Evidence suggested that the strength model should not be applied generally without proper calibration in the range of geometry of interest.

CASI

Bolted Joints; Fabrics; Failure Analysis; Failure Modes; Fasteners; Fracture Strength; Graphite-Epoxy Composites; Laminates

19930001320 Missouri Univ., Rolla, MO, USA

Analysis of failure modes in ceramic matrix composite

Chai, L., Missouri Univ., USA; Dharani, L. R., Missouri Univ., USA; Carleton Univ., Proceedings of the Twelfth Canadian Congress of Applied Mechanics, Volumes 1 and 2; May 1, 1989, pp. p 322-323; In English; See also N93-10466 01-31; Copyright; Avail: Issuing Activity (Canadian Society for Mechanical Engineering, 2050 Mansfield St., Suite 700, Montreal, Quebec H3A 1Z7 Canada), Unavail. Microfiche

A micromechanics analytical model, a two phase consistent shear lag model, is developed for predicting the failure modes in a fiber reinforced unidirectional ceramic matrix composite. The model is based on a modified shear lag theory that accounts for the relatively large matrix stiffness. The fiber and matrix stresses are established as functions of the applied stress, crack geometry, and most importantly, the microstructural properties of the constituents. From the predicted stresses, the modes of failure are established. The following specific damage configurations in a unidirectional ceramic matrix composite subject to uniaxial tensile loading parallel to the fibers are addressed: a transverse crack formed by fracture of both the fiber and the matrix phases with no interface damage, and with interface damage (mode-1) and a transverse matrix crack bridged by intact fibers with no interface damage, and with interface damage (mode-2). A comparison of stresses between mode-1 and mode-2 shows that the maximum stresses corresponding to mode-1 are much higher than those of mode-2. Therefore, a brittle matrix reinforced by fibers which are of higher failure strain than that of the matrix results in a more desirable composite system as it would exhibit crack bridging failure mode. The crack propagation for the failure mode-2 under the constant applied load is of steady state cracking and that for failure mode-1 is that of unstable cracking. The preliminary predictions show that a transition from one failure mode to another is possible.

Author (CISTI)

Ceramic Matrix Composites; Cracking (Fracturing); Failure Analysis; Failure Modes; Fiber Composites; Micromechanics; Stress Analysis

19930003824 Maryland Univ., College Park, MD, USA

Structural integrity of composites under load and thermal insult

Milke, James Albert, Maryland Univ., USA; Jan 1, 1991; 280p; In English; Avail: Univ. Microfilms Order No. DA9222733, Unavail. Microfiche

The failure of loaded composite structures exposed to moderate heating conditions for short durations is examined experimentally and analytically using a first-order thermomechanical model. Observations pertaining to the heat flux, load, and time-to-failure are summarized in a three-dimensional failure surface. The experimental and analytical efforts complement each other to develop a broad-based understanding of the conditions leading to failure. Two sets of small-scale tests are performed, one to acquire elevated temperature material property data of a glass-reinforced, thermoplastic composite. The other set of tests are used to provide insight into the failure mechanisms as well as to formulate the failure surface of composite laminates exposed to asymmetric heating conditions. The analytical model includes three-dimensional thermal and structural response analyses. A progressive failure analysis is conducted to account for the sequence of ply failures leading to laminate failure. Reasonable agreement is obtained between the predictions from the thermal and structural response models and the experimental data. Both experimental and analytical results indicate that char depth and temperature are inadequate predictors of failure. The char depth varies with the level of damage in addition to the severity of the thermal insult. The time-to-failure increases with decreasing flux for all laminates. Differences in the time-to-failure for the three layups increase with decreasing heat flux or load. Thus, at low flux or load levels, the phenomenon is multi-dimensional; whereas at high flux or load levels, failure is one-dimensional.

Dissert. Abstr.

Failure Analysis; Failure Modes; Laminates; Structural Analysis; Structural Failure; Temperature Effects; Thermal Analysis; Thermodynamics

19930013854 Virginia Polytechnic Inst. and State Univ., Dept. of Aerospace and Ocean Engineering., Blacksburg, VA, USA
Compression strength failure mechanisms in unidirectional composite laminates containing a hole *Final Report, 1 Jun. 1981 - 1 Jun. 1989*

Johnson, Eric R., Virginia Polytechnic Inst. and State Univ., USA; Apr 1, 1993; 16p; In English

Contract(s)/Grant(s): NAG1-201

Report No.(s): NASA-CR-192813; NAS 1.26:192813; Avail: CASI; A03, Hardcopy; A01, Microfiche

Experiments on graphite-epoxy laminated plates containing unloaded small holes show that these laminates are notch insensitive. That is, the uniaxial strength of these laminates with small holes exceeds the strength predicted by a point stress criterion using the stress concentration factor for the in-plane stress field. Laminates containing large holes exhibit notch sensitive behavior and consequently their strength is reasonably well predicted by the stress concentration effect. This hole size effect is manifested both in tension and in compression. Apparently, some mechanism must cause in-plane stress relief for laminates containing small holes. The purpose of this research was to study the influence of geometric nonlinearity on the micromechanical response of a filamentary composite material in the presence of a strain gradient caused by a discontinuity such as a hole. A mathematical model was developed at the micromechanical level to investigate this geometrically nonlinear effect.

Author

Composite Materials; Compressive Strength; Failure Analysis; Failure Modes; Graphite-Epoxy Composites; Hole Geometry (Mechanics); Holes (Mechanics); Laminates; Micromechanics; Plates (Structural Members); Stress Analysis; Structural Failure

19930014514 Southwest Research Inst., San Antonio, TX, USA

Characterization of mechanical damage mechanisms in ceramic and polymeric matrix composite materials *Topical Technical Report, Oct. 1991 - Oct. 1992*

Lankford, James, Jr., Southwest Research Inst., USA; Dec 1, 1992; 79p; In English

Contract(s)/Grant(s): N00014-92-C-0093

Report No.(s): AD-A260129; REPT-06-5035; Avail: CASI; A05, Hardcopy; A01, Microfiche

In order to better establish the fundamental mechanisms responsible for the onset of microstructural instability during compressive loading, several fiber-reinforced polymeric matrix composites were tested under conditions involving hydrostatic confinement. It was found that the dependence of strength upon pressure was mild, indicating that the overwhelming factor in the compressive failure of these materials, irrespective of fiber type, matrix, composition, and composite architecture is resistance to shear loading; dilatational mechanisms, certainly ones associated with microfracture, are relatively insignificant. Specific strength levels do appear to be controlled by both inelastic and plastic flow properties of the matrix, and reflect the degree to which the matrix can restrain either the flexure of locally misaligned fibers, or the shear displacement of non-axial cross-ply fibers in more complex composite lay-ups.

DTIC

Ceramic Matrix Composites; Compression Loads; Failure Analysis; Failure Modes; Fiber Composites; Fracture Mechanics; Hydrostatics; Microcracks; Microstructure; Polymer Matrix Composites

19930015028 Drexel Univ., Philadelphia, PA, USA

Time-temperature analysis of damage initiation and growth in composite laminates

Nagesh, Suresh, Drexel Univ., USA; Jan 1, 1992; 137p; In English; Avail: Univ. Microfilms Order No. DA9237891, Unavail. Microfiche

Polymer-based composites are used in aerospace structures due to their high strength to weight ratio. However, polymers also exhibit time-dependent behavior and this behavior may in turn be affected by high temperature and humid environments. Long-term effects manifest themselves in the form of loss of stiffness and/or strength. And, in this regard, the contributing factors could stem from the time-dependent material behavior as well as the accumulation of damages in time. Clearly, a generic methodology is needed which addresses the fundamental issues caused by both of the contributing factors. The objective of the present study is to investigate the time-dependent damage initiation and growth behavior associated with the various sublaminar damage modes in polymer-based composites. A quasi-three dimensional finite element procedure is first developed based on the linear theory of viscoelasticity for simulating sublaminar damages in composite laminates. Specifically the unidirectional plies of the laminate are represented by a set of linear anisotropic, viscoelastic constitutive relations. Damage modes in the forms of transverse cracks, delamination, or fiber-wise splitting are incorporated in the analysis by means of appropriately evolving local boundary conditions. Calculation of the stress fields and fracture parameters such as the strain energy release rates (G) and the stress intensity factors (K) associated with the different modes of damage and at different stages of evolution are also made a part of the routine. Numerical solutions are obtained by a convolution as well as a quasi-elastic technique. To illustrate the applicability of the numerical routine, the problem of fiber-wise splitting is chosen. Since fiber-wise splitting is a mixed-mode type of failure,

an appropriate mixed-mode fracture criterion is needed for predicting its onset and growth. An effort is then made to develop such a criteria, based on experimental data using several aerospace grade graphite-epoxy composite systems. The finite element procedure in conjunction with the fracture criterion is then used to simulate fiber-wise splitting experiments that were conducted previously. Good correlation between the predicted results and the experimental results was obtained.

Dissert. Abstr.

Failure Analysis; Failure Modes; Finite Element Method; Graphite-Epoxy Composites; Laminates; Time Dependence; Time Temperature Parameter

19930016527 Case Western Reserve Univ., Cleveland, OH, USA

Damage and failure analysis on continuous fiber-reinforced polymer composites

Chen, Fuh-Sheng, Case Western Reserve Univ., USA; Jan 1, 1992; 178p; In English; Avail: Univ. Microfilms Order No. DA9306102, Unavail. Microfiche

In chapter one, the damage that accompanies flexural deformation of a unidirectional glass fiber reinforced polyphenylene sulfide composite was examined by acoustic emission (AE) and scanning electron microscopy (SEM). The flexural stress-strain curve was nominally linear to about 1.0 percent strain, but the onset of damage detectable by AE occurred at 0.3 percent strain. Two peaks in the AE amplitude distribution were observed at 35dB and 60dB. Low amplitude events were detected along the entire length of the specimen. SEM observations suggested that these events arose from matrix cracking and fiber debonding. High amplitude events occurred primarily in the region of highest flexural stress between the inner loading points, they were attributed to fracture of glass fibers on the tension side and surface damage on the compressive side. In chapters two and three, the effects of the matrix modulus on the compressive failure mechanisms in flexure of unidirectional glass fiber reinforced thermoplastic Hytel composites has been studied. An increase in the matrix Young's modulus leads to a change in the failure mode from cooperative fiber microbuckling to delamination splitting microbuckling. Cooperative fiber microbuckling is a catastrophic phenomenon without significant damage occurring in the composite system prior to the abrupt failure. Fibers are buckled both in the plane and normal to the plane of the compression surface. Delamination splitting microbuckling is associated with matrix splitting and consists of gradual accumulation of localized surface delaminations followed by buckling of fiber bundles. The transition in the mechanisms of flexural failure is semi-quantitatively explained by considering the criterion for each of the failure modes. The failure strength for cooperative fiber microbuckling is controlled by the shear modulus of the composite which is linear related to the Young's modulus of the matrix, while the failure strength for delamination splitting microbuckling is controlled by the composite shear strength which is not strongly affected on the Young's modulus of the matrix. Because the critical failure stresses have different dependencies on the matrix modulus, a transition from cooperative fiber microbuckling to delamination splitting microbuckling occurs as the matrix modulus increases.

Dissert. Abstr.

Damage; Debonding (Materials); Deformation; Delaminating; Failure Analysis; Failure Modes; Fiber Composites; Flexing; Glass Fiber Reinforced Plastics; Polymer Matrix Composites; Resin Matrix Composites

19930035123

Should fibrous composite failure modes be interacted or superimposed?

Hart-Smith, L. J., Douglas Aircraft Co., USA; Composites; 1993; ISSN 0010-4361; 24, 1, pp. 53-55.; In English; Copyright; Avail: Issuing Activity

It is shown that the theory of Tsai and Wu (1971), which suggests that a change in either longitudinal, transverse-tensile, or transverse-compressive measured strengths will alter every point on the predicted failure envelope of a fibrous composite is physically unrealistic. It is further shown that the application of Hill's (1971) theory to a heterogeneous material should require separate failure envelopes for every possible mode of failure for each of the constituents. These envelopes should then be superimposed with the governing failure envelope defined by the minimum common area. Four different measured strengths for four different failure modes under different states of stress in composite laminates should be sufficient to create four separate failure envelopes and not be combined into a single curve drawn through four unrelated data points.

AIAA

Failure Analysis; Failure Modes; Fiber Composites; Laminates

19940032398 Alberta Univ., Dept. of Mechanical Engineering., Edmonton Alberta, Canada

Analysis and failure of laminated fiber reinforced composites

Elkadi, Hany A., Alberta Univ., Canada; Jan 1, 1993; 279p; In English; ISBN 0-315-88235-2; Copyright; Avail: Micromedia Ltd., Technical Information Centre, 240 Catherine Street, Suite 305, Ottawa, Ontario, K2P 2G8, Canada, Hardcopy, Unavail. Microfiche

Failure modes for fiber reinforced composites (FRC's) are reviewed and factors influencing failure under cyclic loading are presented. Phenomenological and mechanistic approaches for determining the properties of composites are compared. The strain energy can be used as a fatigue failure criterion for unidirectional FRC's. The relation between strain energy and number of reversals to failure was found to be of a power law type which applies to different material types. To include the effect of the stress ratio in the formulation, a nondimensional form of the strain energy is used. This parameter correlates fairly well with experimental data. The strain energy may also be used as a criterion to predict crack growth direction in lamina under static off-axis and in-plane mixed-mode loading. To extend the use of the strain energy criterion to laminates, an existing theory of isotropic laminated plates is extended to include the effect of anisotropy. This theory satisfies all the interlaminar interface traction and displacement continuity conditions as well as the zero-traction condition on the lateral surfaces. Results obtained using this method are presented and the problems arising from using thick laminates with high anisotropy are discussed. These results are also compared to those obtained using three dimensional finite element analysis.

Author (CISTI)

Anisotropic Plates; Crack Propagation; Failure Analysis; Failure Modes; Fatigue (Materials); Fiber Composites; Laminates; Plate Theory

19940037440

New failure criterion for nonlinear composite materials

Abu-Farsakh, G. A., Jordan Univ., USA; Abdel-Jawad, Y. A.; Journal of Composites Technology and Research; April 1994; ISSN 0884-6804; 16, 2, pp. 138-145; In English; Copyright; Avail: Issuing Activity

A new failure criterion based on the total strain energy density approach is introduced for an equivalent linear elastic material. The total strain energy is composed of the elastic strain energy and the plastic strain energy. The proposed criterion can be used to predict failure of fibrous composite materials subject to uniaxial, biaxial, or multiaxial stress state. The proposed criterion takes into account the different behavior of bimodular composites in tension and compression. Given the stress-strain diagrams in the principal material directions, the failure of the material at any fiber orientation angle under an imposed stress state can be predicted. The results are compared with the corresponding available experimental data. In addition, the predicted failure stresses are compared with those obtained using available failure criteria.

Author (EI)

Axial Stress; Criteria; Failure Analysis; Failure Modes; Fiber Composites; Fiber Orientation; Stress-Strain Diagrams

19950009159 Los Alamos National Lab., NM, USA

Computational modeling of fiber-reinforced composites

Addressio, F. L., Los Alamos National Lab., USA; Aidun, J. B., Los Alamos National Lab., USA; Jan 1, 1994; 5p; In English; World Congress on Computational and Applied Mathematics, 11-15 Jul. 1994, Atlanta, GA, USA

Contract(s)/Grant(s): W-7405-ENG-36

Report No.(s): DE94-012914; LA-UR-94-1520; CONF-940719-3; Avail: CASI; A01, Hardcopy; A01, Microfiche

A homogenization technique for simulating the dynamic response of metal-matrix composites has been implemented into EPIC, a three-dimensional, finite-element computer program. The technique includes a micromechanical model for the elastic-plastic response of the constituents. New additions to the constitutive description were a nonlinear mean stress-volumetric strain relation, a rate-form flow stress model, and four micromechanical failure modes. Preliminary simulations of Taylor impact tests gave satisfactory results; the composite anisotropy was well represented and the damage effects were qualitatively correct. The calculations were slowed by less than 20% using the micromechanical homogenization model explicitly. Computing speed should be recovered substantially for matrix yield models like viscoplasticity that permit direct calculation of the plastic strain. The metal plasticity model requires solving for the microvariables twice each time step. The present approach can be extended to epoxy or ceramic composites by inclusion of appropriate constitutive relations.

DOE

Computerized Simulation; Dynamic Loads; Dynamic Response; Failure Analysis; Failure Modes; Fiber Composites; Metal Matrix Composites; Stress-Strain Relationships

19950025687 Michigan Univ., Ann Arbor, MI, USA

Failure mechanisms in composite plates subjected to in-plane compressive loading

Khamseh, Amir Reza, Michigan Univ., USA; Jan 1, 1994; 157p; In English; Avail: Univ. Microfilms Order No. DA9423229, Unavail. Microfiche

An experimental investigation into the failure mechanisms of composite plates in the presence of stress gradients, generated by circular cutouts, subjected to uniaxial/biaxial compressive loading was carried out. The focus of the study was identification

and analysis of the failure initiation mechanisms in laminated plates as a function of the centrally located circular hole and loading parameters. The experimental investigation was divided into two parts, the first dealing with single axis loading and the second addressing biaxial loading. The materials under investigation were comprised of a set of specially designed single layer unidirectional composites, as well as a series of 48 layer graphite/epoxy specimens with varying stacking ply orientation, provided by NASA Langley. Test specimens containing plies oriented in the direction of loading subjected to uniaxial loading exhibited failure initiation along the edge of the hole, perpendicular to the fiber and loading direction, traversing into the specimen in the form of fiber kinking, followed by delamination (i.e. several of the specimens exhibited fiber kinking failure with no evidence of delamination, or delamination growth lagging behind the kink tip). The above mentioned specimens subjected to biaxial loading exhibited similar failure mechanisms as their uniaxial counterparts, but failure initiation was in the form of fiber-matrix debonding. Shear dominated specimens, which have fibers oriented at 45 deg angles to the loading direction, exhibited highly nonlinear strain to failure values with no indication of localized fiber failure. The failure mode for these type of composites was shear induced delamination caused by large wavelength in-plane fiber microbuckling. A computational approach was employed to simulate some of the uniaxial experimental results, through the use of the finite element method. The finite element analysis software HKS-ABAQUS was used, taking into account material nonlinearities. The computational analysis revealed the roles of fiber failure strain and hole gradient in the in-plane failure analysis of composite plates. This investigation has yielded results and shown trends in the failure patterns of composites and the results reported herein can be incorporated in developing their micromechanics based failure criteria.

Dissert. Abstr.

Compression Loads; Failure Analysis; Failure Modes; Fiber Composites; Holes (Mechanics); Laminates; Plates (Structural Members); Stress Distribution; Structural Failure

19950054443

Void/bridged-crack interactions and their implications for defect coalescence

Chandra, A., University of Arizona, Tucson, AZ, USA; Hu, K. X., University of Arizona, Tucson, AZ, USA; International Journal of Damage Mechanics; July 1994; ISSN 1056-7895; 3, 3, pp. 290-307; In English

Contract(s)/Grant(s): NSF DMC-86-57345; Copyright; Avail: Issuing Activity

Void-crack interactions with crack bridging play an important role in the determination of rupture failure models of composite materials. In this paper, an integral equation approach is developed to study the behavior of systems containing multiple interacting voids and cracks with a general form of crack bridging. The formulation is based on a superposition technique that decomposes the interacting voids and cracks into a number of subproblems, each involving only a single crack. The integral equations are fully non-singular and thus can be solved effectively with a Gauss integration scheme. Numerical examples are given in order to study the effects of bridging, bridging anisotropy, void size, and void spacing, among others, on the crack-tip behavior. The influence of void-crack interactions on the fracture path are also investigated. For a material containing doubly periodic collinear holes arranged with offsets in subsequent rows, it is found that the fracture path can be formed either by the coalescence of the holes in a row or by the coalescence of the hole across neighboring rows, depending on the ratio of vertical to horizontal void spacing.

Author (Herner)

Composite Materials; Crack Bridging; Crack Propagation; Cracks; Failure Analysis; Failure Modes; Fracture Mechanics; Holes (Mechanics); Voids

19950059621

Reliability analysis of composite laminates by enumerating significant failure modes

Zhao, Huixia, Clarkson Univ, USA; Gao, Zhanjun; Journal of Reinforced Plastics and Composites; May 1995; ISSN 0731-6844; 14, 5, pp. 427-444; In English; Copyright; Avail: Issuing Activity

In reliability analysis of laminated composite systems, there is a need for an efficient method to distinguish the significant failure modes from the great number of possible failure modes due to the variability in both strengths and loading. Two new concepts, Minimum Failure Load (ML) and Critical Failure Load (CL), are introduced in this paper to enumerate the significant failure modes. Here ML denotes the load level under which there is little-to-none chance a layer, which is defined as laminae with the same orientation, would fail; CL denotes the load level above which the layer will definitely fail. The Weibull distribution formulation for the uniaxial strengths of a layer, the Tsai-Hill failure criterion and Monte Carlo simulation are adopted to determine the values of ML and CL. All the significant failure modes can be enumerated by comparison the values of ML and CL between layers. It has been found that there are basically two groups of failure modes for axial loading and shear loading, respectively, which can be used for selecting the significant failure modes for general in-plane loading. The overall probability of failure and

reliability for the laminate as a function of load are obtained by reliability analysis. The predicted failure sequences show good consistence with the experiment results.

Author (EI)

Critical Loading; Failure Analysis; Failure Modes; Laminates; Monte Carlo Method; Probability Theory; Reliability

19960003819 Missouri Univ., Rolla, MO, USA

Failure analysis of high-temperature composites

Zhao, Yonglu, Missouri Univ., USA; Jan 1, 1993; 113p; In English; Avail: Univ. Microfilms Order No. DA9417907, Unavail. Microfiche

A micromechanics analytical model is developed for predicting the failure modes in fiber reinforced ceramic matrix composite laminates at high temperatures. The model is also modified to facilitate the study of interface debonding and/or frictional slipping in a bimaterial system. The consistent shear lag theory is used in representing the constitutive relations. The governing equations are solved satisfying the boundary conditions appropriate to the damage mode by making use of an eigenvalue technique. The failure modes are predicted based on point stress failure criterion. For composites with weak fibers but strong fiber/matrix interfaces, the crack will propagate in a self-similar mode. For those with relatively weak fiber/matrix interfaces, interface debonding and frictional slipping will occur and a secondary crack away from the original crack plane will be initiated. For strong fiber composites, the crack will propagate in the matrix at the crack tip forming fiber bridged matrix cracking, and when the interface friction is high, the bridging fibers at the crack center will break and cause a catastrophic crack extension. The difference between the thermal expansion coefficients of fibers and matrix can alter the stress distribution. Thermal stresses make the crack surfaces zigzag but remain closed. Higher matrix thermal expansion coefficient can help to lower the longitudinal stress in matrix and transverse normal stress on the fiber/matrix interfaces. Both stresses and strain energy release rate vary linearly with thermal mismatch.

Dissert. Abstr.

Ceramic Matrix Composites; Crack Propagation; Failure Analysis; Failure Modes; Fiber Composites; Fracture Mechanics; High Temperature; Laminates; Micromechanics

19960045790 NASA Langley Research Center, Hampton, VA USA

Test and Analysis of Composite Hat Stringer Pull-off Test Specimens

Li, Jian, NASA Langley Research Center, USA; O'Brien, T. Kevin, Army Research Lab., USA; Rousseau, Carl Q., Bell Helicopter Co., USA; Jun. 1996; 34p; In English

Contract(s)/Grant(s): RTOP 505-63-50-04

Report No.(s): NASA-TM-110263; NAS 1.15:110263; ARL-MR-327; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

Hat stringer pull-off tests were performed to evaluate the delamination failure mechanisms in the flange region for a rod-reinforced hat stringer section. A special test fixture was used to pull the hat off the stringer while reacting the pull-off load through roller supports at both stringer flanges. Microscopic examinations of the failed specimens revealed that failure occurred at the ply termination in the flange area where the flange of the stiffener is built up by adding 45/-45 tape plies on the top surface. Test results indicated that the as-manufactured microstructure in the flange region has a strong influence on the delamination initiation and the associated pull-off loads. Finite element models were created for each specimen with a detailed mesh based on micrographs of the critical location. A fracture mechanics approach and a mixed mode delamination criterion were used to predict the onset of delamination and the pull-off load. by modeling the critical local details of each specimen from micrographs, the model was able to accurately predict the hat stringer pull-off loads and replicate the variability in the test results.

Author

Flanges; Rods; Reinforcing Materials; Composite Materials; Failure Modes; Failure Analysis; Finite Element Method; Stringers; Delaminating; Compression Tests

19970009369 Purdue Univ., School of Astronautics and Aeronautics, West Lafayette, IN USA

Comparative Evaluation of Failure Analysis Methods for Composite Laminates Final Report

Sun, C. T., Purdue Univ., USA; Quinn, B. J., Purdue Univ., USA; Tao, J., Purdue Univ., USA; Oplinger, D. W., Purdue Univ., USA; May 1996; 134p; In English

Report No.(s): AD-A310352; DOT/FAA/AR-95/109; No Copyright; Avail: CASI; A07, Hardcopy; A02, Microfiche

Over the last three decades, there have been continuous efforts in developing failure criteria for unidirectional fiber composites and their laminates. Currently, there exist a large number of lamina failure criteria and laminate failure analysis methods. In this project, a comprehensive and objective study of lamina and laminate failure criteria was performed. Comparisons

among the commonly used failure criteria were made for failure in unidirectional composites under various loading cases. From these comparisons, the characteristics of these criteria were identified and discussed. Further, with the aid of some limited experimental lamina and laminate strength data available in the literature and new data generated by the authors, an attempt was made to select the failure criteria and laminate analysis methods that are mechanistically sound and are capable of accurately predicting lamina and laminate strengths for states of combined stresses. It was found that those lamina failure criteria which separate fiber and matrix failure modes most accurately predict lamina and laminate strength.

DTIC

Failure Analysis; Failure Modes; Fiber Composites; Composite Materials; Laminates

1998009890 Boeing Defense and Space Group, Materials Processes and Physics Technology Div., Seattle, WA USA

Composite Failure Analysis Handbook Final Report

Walker, Gregory M., Boeing Defense and Space Group, USA; Aug. 1997; 264p; In English

Contract(s)/Grant(s): F33615-86-C-5071; AF Proj. 2418

Report No.(s): AD-A330037; DOT/FAA/AR-96/21; WL,XC-TR-93-4004; No Copyright; Avail: CASI; A12, Hardcopy; A03, Microfiche

This report contains fractographic data from failed composite test specimens as well as case histories of failed composite structure. Fractographic data from statically loaded test specimens are presented for carbon/epoxy (AS4/3501-6), carbon/pseudothermoplastic (AS4/KIII), carbon/polyimide (AS4/PMR-15), carbon/thermoplastic (AS4/PEEK), carbon/bismaleimide (AS4/MR-54-4), and carbon and glass low-temperature curing epoxy, (HTA 5131-12K/Rutapox L-20/SL and EC 9-756/K43/Rutapox L-20/SL) materials. Fractographic data are presented for translaminar and interlaminar carbon/resin laminate fatigue specimens, as well as for several failure modes in composite skin nomex honeycomb core specimens. Three failure investigations, including two composite honeycomb structures and one carbon/epoxy laminate structure, are also documented.

DTIC

Composite Structures; Failure Analysis; Handbooks; Failure Modes

19980101802

Fiber/matrix interface studies using fragmentation test

Armistead, J. P., U.S. Navy, Naval Research Lab., USA; Snow, Arthur W., U.S. Navy, Naval Research Lab., USA; 1996, pp. 168-181; In English; Copyright; Avail: AIAA Dispatch

Some fiber-resin composite interface work done at the Naval Research Laboratory is reviewed beginning with several applied studies and progressing to more fundamental work. Butadiene (diacetylene) was evaluated as a novel carbon-fiber surface treatment applied via vapor deposition polymerization. Results of its application to high-strength carbon fibers, high-modulus carbon fibers, and aramid fibers are summarized. Reduction of carbon-fiber surface polarity by annealing under hydrogen was evaluated as a means to decrease the sensitivity of the interface to moisture. In the above experiments the fragmentation test was used to determine relative levels of adhesion and the mechanisms of failure at the fiber/matrix interface. Comparisons of the adhesion of high-modulus and high-strength carbon fibers to epoxy and cyanate matrices were used to evaluate models for the fragmentation test. For high-modulus fibers the adhesion was poor and a friction factor approach may be suitable for modeling this type of interfacial failure. For high-strength fibers the adhesion was much higher and possibly limited by the shear properties of the matrix. The simple mechanics models discussed previously do not explain adhesion changes where chemistry is the only variable. In a study of three matrix resins with comparable mechanical properties, a linear dependence was shown between measured 'good' adhesion and relative resin model compound basicity.

Author (AIAA)

Load Tests; Fragmentation; Fiber Strength; Failure Modes; Failure Analysis; Fracture Mechanics

19980155534

Failure properties of creep prestrained glass-woven fabric composites

Pyrz, R., Aalborg, Univ., Denmark; Science and Engineering of Composite Materials; 1994; ISSN 0334-181X; Volume 3., no. 1, pp. 29-38; In English; Copyright; Avail: Aeroplus Dispatch

The strength properties of composite materials may alter due to prior mechanical loading as a consequence of internal structural rearrangements. The failure behavior of woven fabric composite subjected to prior creep deformation is studied in this paper. The invariant form of the failure criterion is specified for a virgin material. The modified version of the criterion is proposed

in order to incorporate preloading effects. Experimental evidence of the strength alteration due to the preloading history corresponds well with the proposed criteria.

Author (AIAA)

Failure Modes; Woven Composites; Prestressing; Creep Strength; Failure Analysis

19980164598

Static strength

Nuismer, Ralph J., Hercules Aerospace Co., USA; Engineered materials handbook. Vol. 1 - Composites; 1993; 1 - Composites, pp. 432-435; In English; Copyright; Avail: Aeroplus Dispatch

The static strength of composite structures under both tension and compression loads is discussed on the basis of a practical, design-oriented approach. Lamina strength, laminate strength, and stress concentrations and damage are considered with regard to continuous fiber composites.

AIAA

Composite Structures; Failure Analysis; Stress Analysis; Laminates; Mechanical Properties; Failure Modes

26

METALS AND METALLIC MATERIALS

Includes physical, chemical, and mechanical properties of metals and metallic materials; and metallurgy.

19730028468

Analyzing failures of metal components.

Dolan, T. J., Illinois, University, USA; Metals Engineering Quarterly; Nov 1, 1972; 12, pp. Nov. 197; In English; p. 32-40; Copyright; Avail: Issuing Activity

The literature contains valuable knowledge from documentation on failures that may be used to develop logical analyses of causes for service failures. Careful investigation, detailed observations, and sorting of a wide variety of information is important in analyzing how and why a part failed. Material selection, design, processing and fabrication, maintenance, and service environment must all be given careful study. All possible modes of a given failure should be considered to assure against its recurrence from unknown factors. A variety of failures are discussed to emphasize the need to foresee the influence of design and processing on response of the metal to the service environment.

AIAA

Component Reliability; Failure Analysis; Failure Modes; Metals

19790040217

Failure mechanisms and metallography - A review

Le May, I., SASKatchewan, University, Canada; Jan 1, 1978; 31p; In English; Metallography in failure analysis; Symposium, July 17-18, 1977, Houston, TX; See also A79-24229 08-26; Copyright; Avail: Issuing Activity

The two basic and distinct mechanisms of fracture are related to cleavage and ductile fracture. The former occurs under tensile stress and involves separation along crystallographic planes with little or no plastic flow taking place, and leads to a brittle appearance of the fracture surface, with a small amount of energy being dissipated. The latter involves plastic deformation by slip, and the energy dissipation involved is much greater, but depends on the extent of the plastic flow. A description is provided of the investigational procedures. Specific failure mechanisms and metallographic evidence are considered, taking into account cleavage, ductile fracture, fatigue, intergranular fracture, environmentally-assisted fracture, and aspects of corrosion and wear.

AIAA

Cleavage; Failure Analysis; Failure Modes; Fracture Strength; Metallography

19890010856 NASA Lewis Research Center, Cleveland, OH, USA

Failure analysis of a Stirling engine heat pipe

Moore, Thomas J., NASA Lewis Research Center, USA; Cairelli, James E., NASA Lewis Research Center, USA; Khalili, Kaveh, Stirling Thermal Motors, Inc., Ann Arbor, USA; Mar 1, 1989; 13p; In English

Contract(s)/Grant(s): RTOP 586-01-11

Report No.(s): NASA-TM-101418; E-4516; NAS 1.15:101418; Avail: CASI; A03, Hardcopy; A01, Microfiche

Failure analysis was conducted on a heat pipe from a Stirling Engine test rig which was designed to operate at 1073 K. Premature failure had occurred due to localized overheating at the leading edge of the evaporator fin. It was found that a crack

had allowed air to enter the fin and react with the sodium coolant. The origin of the crack was found to be located at the inner surface of the Inconel 600 fin where severe intergranular corrosion had taken place.

CASI

Failure Analysis; Failure Modes; Heat Pipes; Intergranular Corrosion; Stirling Engines

19960048933

Methodology to derive the implicit equation of failure criteria for fibrous composite laminates

Echaabi, James, Ecole Polytechnique, Canada; Trochu, Francois; Journal of Composite Materials; 1996; ISSN 0021-9983; 30, 10, pp. 1088-1114; In English; Copyright; Avail: Issuing Activity

Strength failure criteria of fibrous composite laminates have been proposed up till now in two different forms: (1) parametric formulations, in which the failure envelope is described by a parametric equation in the stress or strain space and (2) implicit formulations, when the failure surface is defined by an implicit equation between failure stresses and strains. A systematic connection between these two types of formulations has not yet been elaborated. Such a connection would permit the combination of the flexibility of the parametric formulation with the simplicity of the implicit criterion. In previous papers (left bracket) 8,10(right bracket) a methodology to derive failure envelopes of composite laminates based on uniaxial failure stresses, physical considerations and/or failure modes has been elaborated. Up till now, only the parametric expression of the criterion has been derived. In this paper, a procedure is proposed to calculate the equivalent implicit equation of a criterion from its parametric expression. Although different failure modes may be described simultaneously by the failure criterion, with dual kriging only one analytical equation is necessary in the stress or in the strain space. This procedure is general and describes the failure of various kinds of composite laminates. The practical relationship with tensional failure criteria is also exposed. Finally, the methodology is applied to a unidirectional graphite-epoxy and to (left bracket) 0/90(right bracket) graphite-epoxy fabrics.

Author (EI)

Failure; Failure Analysis; Failure Modes; Fiber Composites; Laminates; Stresses

19980106427

Forecasting metallic material creep and failure under static loading

Teteruk, R. G., Kiev State Univ., Ukraine; 1996, pp. 205-212; In English; Copyright; Avail: AIAA Dispatch

The problem of forecasting the long-term strength of materials under stationary loading is considered. The applicability of the Genki-Hoff viscous flow concept and its modifications for solving problems of such a class is analyzed, for the case of metallic materials. The paper also considers the creep model based on the isochrone diagram-similarity principle, describing all the three stages of the process without involving the damageability function. A new procedure for determining the rheological constants is proposed for the given model, using the spline function. It is shown that the present model can be used for forecasting the fatigue life of materials which fail by the brittle and mixed mode, and the Hoff model for materials failing by the toughness fracture mode.

Author (AIAA)

Metal Fatigue; Creep Strength; Failure Analysis; Static Loads; Failure Modes; Spline Functions

19980149401

Failures of structures and components by environmentally assisted cracking

Lynch, S. P., Defence Science and Technology Organisation, Aeronautical and Maritime Research Lab., Australia; Engineering Failure Analysis; Jun. 1994; ISSN 1350-6307; Volume 1, no. 2, pp. 77-90; In English; Copyright; Avail: Aeroplus Dispatch

General procedures for analyzing failures, especially where environmentally assisted cracking is suspected, are outlined. Specific examples of failures due to, for example, stress cracking, corrosion fatigue, hydrogen embrittlement and liquid-metal embrittlement in aluminum alloys, high-strength steels, and other materials are described, and possible ways of preventing such failures are suggested. Failures of high-strength steel components and ways of differentiating between the many failure modes which can produce brittle intergranular fractures along prior-austenite grain boundaries are discussed in particular.

Author (AIAA)

Structural Failure; Failure Analysis; Failure Modes; Structural Members

NONMETALLIC MATERIALS

Includes physical, chemical, and mechanical properties of plastics, elastomers, lubricants, polymers, textiles, adhesives, and ceramic materials. For composite materials see 24 Composite Materials.

19840007969 Mississippi State Univ., Dept. of Chemical Engineering., State College, MS, USA

An evaluation of Techroll seal flexible joint material

Hall, W. B., Mississippi State Univ., USA; Alabama Univ. Res. Rept.: 1983 NASA(ASEE Summer Faculty Fellowship Program; Dec 1, 1983, pp. 18 p; In English; See also N84-16022 06-80; E06

This study evaluated the materials utilized in the flexible joint for possible failure modes. Studies undertaken included effect of temperature on the strength of the system, effect of fatigue on the strength of the system, thermogravimetric analysis, thermochemical analysis, differential scanning calorimeter analysis, dynamic mechanical analysis, and peel test. These studies indicate that if the joint failed due to a materials deficiency, the most likely mode was excessive temperature in the joint. In addition, the joint material is susceptible to fatigue damage which could have been a contributing factor.

B.W.

Failure Analysis; Failure Modes; Inertial Upper Stage; Seals (Stoppers); TDR Satellites

19850020756 Battelle Columbus Labs., OH, USA

Properties of polyethylene gas piping materials *Report, Jan. - Dec. 1983*

Cassady, M. J., Battelle Columbus Labs., USA; Uralil, F. S., Battelle Columbus Labs., USA; Lustiger, A., Battelle Columbus Labs., USA; Hulbert, L. E., Battelle Columbus Labs., USA; Dec 1, 1984; 225p; In English

Report No.(s): PB85-187045; N-4559; GRI-84/0169; Avail: CASI; A10, Hardcopy; A03, Microfiche

The material properties and material behavior for selected polyethylene piping materials which have been generated over the past eleven years are summarized. The material properties evaluated include density, melt flow, molecular weight, tensile properties, slow crack growth resistance, quick burst strength, rotary fatigue strength, environmental stress crack resistance and stress rupture.

CASI

Durability; Failure Analysis; Failure Modes; Pipes (Tubes); Polyethylenes

19920019172 Southwest Research Inst., San Antonio, TX, USA

Study of high temperature failure mechanism in ceramics *Final Report, Dec. 1989 - Sep. 1991*

Page, Richard A., Southwest Research Inst., USA; Lankford, James, Southwest Research Inst., USA; Chan, Kwai S., Southwest Research Inst., USA; Jan 1, 1992; 80p; In English

Contract(s)/Grant(s): F49620-88-C-0081

Report No.(s): AD-A247018; SWRI-2253/3; AFOSR-92-0012TR; Avail: CASI; A05, Hardcopy; A01, Microfiche

This final report documents the results of a basic research program aimed at: (1) studying the high temperature failure mechanisms in ceramics; (2) establishing relationships between cavitation mechanisms and creep crack growth characteristics; and (3) developing a damage mechanism-based life prediction model. The growth rate, near-tip creep responses, and damage processes of creep cracks in a pyroceram glass-ceramic were studied under tensile loading at elevated temperatures. The results of these studies indicated that creep crack growth in the pyroceram glass-ceramic occurred both in continuous and discontinuous manners, with the damage processes manifested as the nucleation, growth, and coalescence of inhomogeneously distributed cavities and microcracks. Sintering of cavities led to the existence of a growth threshold below which the creep crack would open, blunt, but not propagate. Measurements of the total accumulated creep strain near the crack-tip revealed that creep crack extension followed a critical strain criterion. Relationships between cavitation mechanisms and creep crack growth characteristics of the glass-ceramic are discussed.

DTIC

Ceramics; Crack Propagation; Damage Assessment; Failure Analysis; Failure Modes; Glass; High Temperature Tests; Microcracks; Pyroceram (Trademark); Tensile Tests

19940019759 Wright Research Development Center, Wright-Patterson AFB, OH, USA

Micromechanical failure modes in brittle matrix composites

Pagano, Nicholas J., Wright Research Development Center, USA; AGARD, Introduction of Ceramics into Aerospace Structural Composites; Nov 1, 1993, pp. 18 p; In English; See also N94-24228 06-27; Copyright; Avail: CASI; A03, Hardcopy; A02, Microfiche

Ceramic-and glass ceramic matrix composites are being touted for application in high temperature structural components. Before their potential can be realized, however, understanding of the significance of the fracture modes that occur at very low stress levels well beneath those commonly assumed to initiate microcracking in the literature, will be essential. Unfortunately, at this point in the technology development, the precise definition of these mechanisms, i.e., the geography of the fracture plane(s), has been described rather incompletely in experimental research. In most cases, the experimental observations only provide views of these cracks at their intersection with a surface of the composite. Thus, in this presentation, we will provide some predictions of failure scenarios based upon a hypothetical idealized initial flaw in the matrix-an annular crack in a plane normal to the fibers of an unidirectional composite. Although many of the properties needed for the modeling study have not been realistically determined, especially the in-situ strength/ fracture properties, and the fracture criteria itself incorporates an undetermined parameter, i.e., initial flaw size, it is hoped that the modeling can serve to determine the nature of the parameters that require measurement and to help establish the sensitivity of the response to these parameters, as well as to guide experimental efforts to attempt validation of the failure processes hypothesized. The complexity of these processes seems to demand an iterative approach between the analyst and experimentalist.

Derived from text

Brittleness; Ceramic Matrix Composites; Failure Analysis; Failure Modes; Fracture Mechanics; Glass; Microcracks; Micromechanics

19960039760

Using failure mode and effects analysis in new glaze introduction

Marchant, David D., Lenox China Manufacturing Div, USA; Stangle, Timothy K.; Ceramic Engineering and Science Proceedings; May 1995; ISSN 0196-6219; 16, 3, pp. 159-164; In English; Copyright; Avail: Issuing Activity

Failure modes and effects analysis (FMEA) tool has been found to be effective in organizing the conversion of a glaze formulation and process of a plant. It is effective in helping to identify weaknesses in the implementation of the process by addressing process weaknesses before the actual implementation. This tool provides a methodical examination of potential failures due to a change in a process. It helps to recognize and evaluate potential failure modes and causes associated with manufacturing, identifies action to eliminate or reduce the potential failure, and documents the process. In this paper, FMEA tool is described and examples of its uses are presented.

Author (EI)

Ceramics; Failure Analysis; Failure Modes; Glazes; Industrial Management; Industrial Plants; Manufacturing

19980046743

Influence of mode-mixity on dynamic failure mode transitions in polycarbonate

Rittel, D., Technion, Israel; Levin, R.; Maigre, H.; Journal De Physique. IV : JP; August, 1997; ISSN 1155-4339; Volume 7, no. 3, pp. 861-866; In English; 1997 5th International Congress on Mechanical and Physical Behaviour of Materials under Dynamic Loading, Sep. 22-26, 1997, Toledo, Spain; Copyright; Avail: Issuing Activity

The transition of a shear to opening type of failure mechanism has been reported for side impact experiments of notched or cracked plates (metallic alloys and polycarbonate). The present paper addresses additional aspects of the phenomenon in relation to mode-mixity for actual fatigue cracks in polycarbonate specimens. Two distinct experimental setups are used and systematically compared throughout the work: dominant mode II and dominant mode I loading. The experimental results show that the same characteristic failure mechanisms operate irrespective of the specimen geometry (loading mode) and crack-tip nature for a given impact velocity (evolution of the stress intensity factors).

Author (EI)

Dynamic Response; Failure Modes; Modal Response; Polycarbonates; Failure Analysis; Cracks; Fatigue (Materials); Impact Tests

19990049528

Simultaneous failures in fiber bundles

Hansen, Alex, Norges Teknisk-Naturvitenskaplige Univ., Norway; Hemmer, Per C., Norges Teknisk-Naturvitenskaplige Univ., Norway; 1998, pp. 1-10; In English; Copyright; Avail: AIAA Dispatch

We discuss two models for the failure of bundles of parallel fibers under increasing load. by studying the burst distribution, i.e., the distribution of the number of fibers that simultaneously fail when the external load is controlled, we show analytically for one of them how the breakdown process approaches a critical point.

Author (AIAA)

Failure Modes; Reinforcing Fibers; Bundles; Failure Analysis; Mathematical Models

PROPELLANTS AND FUELS

Includes rocket propellants, igniters and oxidizers; their storage and handling procedures; and aircraft fuels. For nuclear fuels see 73 Nuclear Physics. For related information see also 07 Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power, and 44 Energy Production and Conversion.

19820007348 Oak Ridge National Lab., Engineering Technology Div., TN, USA

Failure modes and effects analysis of a coal-slurry preheater

Mitchell, H. A., Oak Ridge National Lab., USA; Parsly, L. F., Oak Ridge National Lab., USA; Smith, A. N., Oak Ridge National Lab., USA; Sep 1, 1981; 33p; In English

Contract(s)/Grant(s): W-7405-ENG-26

Report No.(s): DE81-030425; ORNL/TM-7664; Avail: CASI; A03, Hardcopy; A01, Microfiche

Some 55 potential failure modes were identified in a coal slurry preheater, a critical component in a typical coal direct liquefaction plant. Fourteen of these events, if they should occur, would result in losses of sufficient magnitude to require special consideration in the design or operating phase to assure control of risk at an acceptable level. It is concluded that the failure modes and effects analysis technique (FMEA) could be a valuable tool in the identification of critical components for coal conversion systems. For maximum effect, FMEA needs to be used during the initial design phase. Its principal value is to determine high-risk failure modes, which could have unacceptable impacts on system safety and reliability/availability. The usefulness of FMEA can be improved if it is supplemented by the development of a failure data base; this data base could also be of value in selected cases as input to a more detailed technique such as a fault-free analysis.

DOE

Coal Liquefaction; Failure Modes; Heating Equipment; Pilot Plants; Slurries; Structural Design Criteria

19900010918 Sandia National Labs., Albuquerque, NM, USA

Pyrotechnic device technology

Wilcox, P. D., Sandia National Labs., USA; Jan 1, 1989; 18p; In English; 14th; International Pyrotechnics Seminar, 18-22 Sep. 1989, Jersey

Contract(s)/Grant(s): DE-AC04-76DP-00789

Report No.(s): DE90-007683; SAND-90-0259C; CONF-8909113-7; Avail: CASI; A03, Hardcopy; A01, Microfiche

The current technology of pyrotechnic devices is surveyed and trends are examined for the future. Pyrotechnic can have several meanings. Pyrotechnic devices here are devices in which porous materials undergo reduction-oxidation reactions and produce useful products. The pyrotechnic materials are generally fuel-oxidizer systems without binders, in contrast to primary or secondary explosives or propellants. The word pyrotechnic is often used to include explosive, squib, propellant, or other ordnance type devices, especially in the European community. The major need for pyrotechnic devices was always military and defense; however, as technology advances, the civilian uses of pyrotechnics will continue to grow. If every automobile had a pyrotechnic device to trigger its air or crash bag, that application alone would mean millions of devices per year. Applications in safety, fire fighting, law enforcement, and other commercial applications are likely to increase due to the increased capability of pyrotechnic devices and the integration of such devices in system designs.

DOE

Chemical Analysis; Failure Analysis; Failure Modes; Mechanical Properties; Pyrotechnics; Specifications; Technology Assessment

19900014258 Rockwell International Corp., Rocketdyne Div., Canoga Park, CA, USA

Health management system for rocket engines *Final Report*

Nemeth, Edward, Rockwell International Corp., USA; Jun 1, 1990; 247p; In English

Contract(s)/Grant(s): NAS3-25625; RTOP 553-13-00

Report No.(s): NASA-CR-185223; NAS 1.26:185223; Avail: CASI; A11, Hardcopy; A03, Microfiche

The functional framework of a failure detection algorithm for the Space Shuttle Main Engine (SSME) is developed. The basic algorithm is based only on existing SSME measurements. Supplemental measurements, expected to enhance failure detection effectiveness, are identified. To support the algorithm development, a figure of merit is defined to estimate the likelihood of SSME criticality 1 failure modes and the failure modes are ranked in order of likelihood of occurrence. Nine classes of failure detection

strategies are evaluated and promising features are extracted as the basis for the failure detection algorithm. The failure detection algorithm provides early warning capabilities for a wide variety of SSME failure modes. Preliminary algorithm evaluation, using data from three SSME failures representing three different failure types, demonstrated indications of imminent catastrophic failure well in advance of redline cutoff in all three cases.

CASI

Computer Programs; Failure Analysis; Failure Modes; Management Systems; Safety Factors; Space Shuttle Main Engine

19950021894 Hercules Aerospace Co., Magna, UT, USA

Hazards analysis of an integral class 1.1/1.3 rocket motor demilitarization and ingredient recovery system using ammonia
Stevens, Philip M., Hercules Aerospace Co., USA; Reed, M. H., Hercules Aerospace Co., USA; Losee, L. A., Hercules Aerospace Co., USA; Hendrickson, K. A., Hercules Aerospace Co., USA; Mitchell, D. H., Hercules Aerospace Co., USA; Johns Hopkins Univ., The 1994 JANNAF Safety and Environmental Protection Subcommittee Meeting, Volume 1; Aug 1, 1994, pp. p 227-238; In English; See also N95-28294 09-20; Avail: Chemical Propulsion Information Agency, Johns Hopkins Univ. 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200, Hardcopy, Unavail. Microfiche

The Department of Defense has a technical requirement to develop alternative technologies to dispose of large numbers of solid propellant rocket motors while minimizing environmental impact. Research efforts conducted at the bench-scale have demonstrated the U.S. Army Missile Command (MICOM) near-critical fluid technology as a viable method of demilitarizing solid rocket motors. This method has been successfully used to recover valuable ingredients, such as cyclotetramethylene tetranitramine (HMX), cyclotrimethylene trinitramine (RDX), ammonium perchlorate (AP), and aluminum (Al)/binder crumb from tactical and strategic Class 1.1 and 1.3 solid propellants. This process utilizes liquid anhydrous ammonia for ingredient extraction and recovery. Under an Army-sponsored effort, Hercules Aerospace Company and Rust International have been awarded a contract to design and construct a pilot plant demilitarization test facility and to demonstrate this technology on Class 1.1 and 1.3 solid propellant tactical rocket motors. This report describes the hazards analysis efforts which have been ongoing since the start of the program. Hazards testing has characterized the sensitivity of propellants, process streams, and extracted materials. Hazards analysis techniques, such as logic diagrams, and failure modes and effects analysis (FMEA), have identified credible hazards in the equipment design and pilot plant operations. These potential hazards have been tracked by a closed loop system and have been mitigated by design features or operating controls. Major hazards identified will be discussed along with methods for mitigation. Also feedback from initial pilot plant operations will be reported to the extent that information is available.

Author

Aluminum; Ammonium Perchlorates; Defense Program; Hazards; HMX; Liquid Ammonia; Materials Recovery; RDX; Solid Propellant Rocket Engines; Solid Rocket Propellants; Systems Engineering; Waste Disposal

19980100768

Failure analysis of ordnance related components - Seventy five years of challenge and frustration

Lai, K. S., Pratt & Whitney, Chemical Systems Div., USA; Pinkham, J. E., Pratt & Whitney, Chemical Systems Div., USA; Bull, R. A., Lockheed Martin Astronautics, USA; Jul. 1997; In English

Report No.(s): AIAA Paper 97-2958; Copyright; Avail: AIAA Dispatch

The complexity of some of the devices used in aerospace applications presents unique challenges in failure investigation and duplication of failure mode. This is usually compounded by extremely limited production and lack of a detailed fault tolerance analysis during the design phase. Experience in using various incidents that were widely diverse in time and occurrence is described to illustrate that the most obvious and generally agreed upon conclusions are often erroneous or false. Moreover, the actual cause of some failures were repetitive and remained obscured for a considerable period of time after the problem was 'solved'. These episodes were only truly resolved after subsequent repeated failures that appeared to be inconsistent with the original findings, and could only be resolved on the premise that the original conclusions were based on false premises.

Author (AIAA)

Failure Analysis; Ordnance; Failure Modes; Ignition

31 ENGINEERING (GENERAL)

Includes general research topics to engineering and applied physics, and particular areas of vacuum technology, industrial engineering, cryogenics, and fire prevention. For specific topics in engineering see categories 32 through 39.

19790022244 Boeing Engineering and Construction Co., Seattle, WA, USA

MOD-2 failure mode and effects analysis

Lynette, R., Boeing Engineering and Construction Co., USA; Poore, R., Boeing Engineering and Construction Co., USA; Jul 1, 1979; 302p; In English; Sponsored by NASA

Contract(s)/Grant(s): DEN3-2; DE-AI01-79ET20485

Report No.(s): NASA-CR-159632; Avail: CASI; A14, Hardcopy; A03, Microfiche

The results of a failure mode and effects analysis of the Mod-2 wind turbine are presented.

CASI

Failure Analysis; Failure Modes; Windpowered Generators

19930013781 Technical Research Centre of Finland, Safety Engineering Lab., Espoo, Finland

Sneak analysis applied to process systems

Whetton, Cris, Sheffield Univ., UK; Jan 1, 1992; 96p; In English

Report No.(s): DE93-752866; VTT-TIED-1376; Avail: CASI; A05, Hardcopy; A01, Microfiche

Traditional safety analyses, such as HAZOP, FMEA, FTA, and MORT, are less than effective at identifying hazards resulting from incorrect 'flow' - whether this be flow of information, actions, electric current, or even the literal flow of process fluids. Sneak Analysis (SA) has existed since the mid nineteen-seventies as a means of identifying such conditions in electric circuits; in which area, it is usually known as Sneak Circuit Analysis (SCA). This paper extends the ideas of Sneak Circuit Analysis to a general method of Sneak Analysis applied to process plant. The methods of SA attempt to capitalize on previous work in the electrical field by first producing a pseudo-electrical analog of the process and then analyzing the analog by the existing techniques of SCA, supplemented by some additional rules and clues specific to processes. The SA method is not intended to replace any existing method of safety analysis; instead, it is intended to supplement such techniques as HAZOP and FMEA by providing systematic procedures for the identification of a class of potential problems which are not well covered by any other method.

DOE

Failure Analysis; Hazards; Safety; Sneak Circuit Analysis

19980129240

Failure analysis and prevention 1995; Proceedings of International Conference on Failure Analysis and Prevention (ICFAP '95), Beijing, China, June 23-26, 1995

1995; In English; ISBN 7-80003-337-6/TB 27; Copyright; Avail: Aeroplus Dispatch

Various papers on failure analysis and prevention are presented. The general topics addressed include: principles and methodology, techniques of failure analysis, design-related failures, materials-processing related failures, service environment-related failures, principles and techniques of failure prevention, failure analysis and prevention in electronics.

AIAA

Structural Failure; Failure Analysis; Prevention; Conferences; Failure Modes

19980225004

Metrics evaluations for environmental and reliability testing

Gibbel, Mark, JPL, USA; Cornford, Steve, JPL, USA; Hoffman, Alan, JPL, USA; Gross, Michael, JPL, USA; 1998, pp. 224-232; In English; Copyright; Avail: Aeroplus Dispatch

NASA's Code QE Test Effectiveness Program is funding a series of applied research activities focused on utilizing the principles of physics and engineering of failure along with those of engineering economics to assess and improve the value added by various validation and verification activities. Presented here in are the latest metric evaluations for the effectiveness of the tests involved in one of JPL's recent space flight programs.

Author (AIAA)

Failure Analysis; Space Flight; Failure Modes

ELECTRONICS AND ELECTRICAL ENGINEERING

Includes development, performance, and maintainability of electrical/electronic devices and components; related test equipment and microelectronics and integrated circuitry. For related information see also 60 Computer Operations and Hardware; and 76 Solid-State Physics. For communications equipment and devices see 32 Communications and Radar.

19730053647

Analysis of integrated circuit failure modes and failure mechanisms derived from high temperature operating life tests. Vetter, R. A., McDonnell Douglas Astronautics Co., USA; Jan 1, 1973; 5p; In English; 11th; Annual Symposium on Reliability physics 1973, April 3-5, 1973, Las Vegas, NV; See also A73-38438 19-09; Copyright; Avail: Issuing Activity

No abstract.

Failure Analysis; Failure Modes; High Temperature Tests; Integrated Circuits; Service Life

19760013287 Plessey Co. Ltd., Towcester, UK

Reliability and failure mode analysis of GaAs FET's at X-band *Final Report, Feb. - Jul. 1975*

Abbott, D. A., Plessey Co. Ltd., UK; Turner, J. A., Plessey Co. Ltd., UK; Jul 1, 1975; 48p; In English

Contract(s)/Grant(s): ESTEC-2308/74-AK

Report No.(s): CD.6500610/K; ESA-CR(P)-778; Avail: CASI; A03, Hardcopy; A01, Microfiche

A series of tests were carried out on commercially available GaAs FET devices of the type GAT 2 and GAT 3. The tests overstressed the devices to accelerate failure so the failure modes could be observed within a short period of time. Tests carried out were: dc burn-in, dc bias, thermal cycling, ac burn-in, RF test, and thermal impedance measurements. Given certain selection criteria the FETs are found to be reliable devices. The main area of concern is the channel region when small irregularities in the metallization definition can accelerate failure. Areas where further investigation would be fruitful are: ohmic contacts and the gate itself with failures caused by spike breakdown.

ESA

Component Reliability; Failure Analysis; Failure Modes; Field Effect Transistors; Superhigh Frequencies

19820058685

Soft failures - The invisible mode

Frank, D. E., Douglas Aircraft Co., USA; Jan 1, 1982; 5p; In English; Annual Reliability and Maintainability Symposium, January 26-28, 1982, Los Angeles, CA; See also A82-42176 21-38; Copyright; Avail: Issuing Activity

In 2-4 years, over 60% of the semiconductor components in avionics will be sensitive to electrostatic charges of less than 100 volts. Such voltages will degrade or even destroy electrostatic discharge sensitive (ESDS) components in the course of manufacture. A proprietary program for the elimination of ESDS system problems is described whose major element is the isolation of failure causes at the site of their occurrence through testing at intermediate points of the manufacturing process. Attention is given to the roles of low humidity environments and spray coatings. All manufacturing areas have been rendered static-free by the elimination of nonmetallic surfaces. It is recommended that device switching frequency derating be undertaken wherever possible, since the effect of electrostatic degradation increases with switching speed.

AIAA

Component Reliability; Electronic Equipment Tests; Electrostatic Shielding; Failure Analysis; Failure Modes; Semiconductor Devices

19850062996

Manufacturing quality from electronic failure analysis results

Dobbs, B., USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, USA; Jan 1, 1984; 8p; In English; NAECON 1984, May 21-25, 1984, Dayton, OH; Sponsored by IEEE; See also A85-44976 21-01; Avail: Issuing Activity

The Electronic Failure Analysis Group of the AFWAL/Materials Laboratory Systems Support Division has investigated numerous electronic device failures that resulted from manufacturing process defects. The electronic failure analysis program that verifies the device failure, locates the failure site, establishes the cause of failure and recommends corrective actions is discussed in relation to improving the quality of electronic devices; performing electronic failure analysis is a high-payoff activity. Corrective actions usually involve very small costs to the manufacturer and provide the user with a large return on investment. Brief case histories are presented in regard to packaging, die attachment, solder flux removal, package moisture content, IC

metallization processes, potted modules, and handling procedures affecting device cleanliness. Situations are identified where better quality control could eliminate many device defects that lead to premature part failure.

AIAA

Electronic Equipment Tests; Failure Analysis; Failure Modes; Manufacturing; Quality Control

19870005982 Sandia National Labs., Albuquerque, NM, USA

Program to analyze the failure mode of lead-acid batteries

Zuckerbrod, David, Westinghouse Research and Development Center, Pittsburgh, USA; Mar 1, 1986; 32p; In English; Prepared for US Nuclear Regulatory Commission

Contract(s)/Grant(s): DE-AC04-76DP-00789

Report No.(s): NUREG-CR-4833; SAND-86-7080; Avail: CASI; A03, Hardcopy; A01, Microfiche

The electrical characteristics of large lead-acid cells from nuclear power plants were studied. The overall goal was to develop non-destructive tests to predict cell failure using this easily obtained information. Cell capacitance, internal resistance, reaction resistance for hydrogen evolution and cell capacity were measured on a lead-calcium cell in good condition. A high float voltage and low internal resistance were found to correlate with good cell capacity in cells selected from a set of six lead-antimony cells in poor conditions.

CASI

Capacitance-Voltage Characteristics; Failure Analysis; Failure Modes; Lead Acid Batteries; Nuclear Power Plants

19910023037 Marconi Electronic Devices Ltd., Lincoln, UK

Simulation of radiation induced circuit failure modes in SOS integrated circuits

Townsend, G. C., Marconi Electronic Devices Ltd., UK; Bird, S. A., Marconi Electronic Devices Ltd., UK; ESA, ESA Electronic Components Conference; Mar 1, 1991, pp. p 387-391; In English; See also N91-32291 24-33; Copyright; Avail: CASI; A01, Hardcopy; A06, Microfiche

The design of radiation hard integrated circuits is discussed. The complex interaction between the several distinct effects of radiation on an individual transistor's characteristic is considered. Existing simulations often examine only one effect at any one time, and then in a crude global manner. The task of predicting the combined effects of these phenomena on a circuit as a whole is difficult, and as a result critical circuit failure mechanisms can often be overlooked. The major radiation effects with which the designer is concerned and some techniques used to predict their combined effect using the SPICE circuit simulator are described. An example of some of the results of this kind of analysis are presented, together with some conclusions drawn from them. Suggestions for future improvements in modeling and simulation techniques are made.

ESA

Circuit Reliability; Failure Analysis; Failure Modes; Integrated Circuits; Prediction Analysis Techniques; Radiation Effects; SOS (Semiconductors)

19910023087 Lawrence Livermore National Lab., Livermore, CA, USA

Development and operation of a solid-state switch for thyatron replacement

Merritt, B. T., Lawrence Livermore National Lab., USA; Dreifuers, G. R., Lawrence Livermore National Lab., USA; Jun 14, 1991; 7p; In English; 8th; IEEE Pulsed Power Conference, 17-19 Jun. 1991, San Diego, CA, USA

Contract(s)/Grant(s): W-7405-ENG-48

Report No.(s): DE91-016553; UCRL-JC-105355; CONF-910640-36; Avail: CASI; A02, Hardcopy; A01, Microfiche

A solid-state switch, consisting of 22 reverse conducting thyristors, has been designed to operate at 20 kV hold-off voltage, 1500 A peak, 57 ARMS, 1.0 microsecond pulse-width, and 4500 pps. to date, 70 switches have been fielded, accumulating over 330,000 unit-hours with a demonstrated MTBF of over 6000 hours. The previously used thyatrons have all been replaced since the solid-state switch has proven to be more reliable. In addition, the solid-state switch is more cost effective due to its ability to be repaired. This paper discusses the design, construction, triggering, operation, reliability, and failure modes of this switch.

DOE

Electric Switches; Failure Analysis; Failure Modes; Mtb; Reliability Analysis; Solid State Devices; Thyatrons

19920002065 Sandia National Labs., Albuquerque, NM, USA

Case history: Failure analysis of a CMOS SRAM with an intermittent open contact

Campbell, A. N., Sandia National Labs., USA; Cole, E. I., Jr., Sandia National Labs., USA; Henderson, C. L., Sandia National Labs., USA; Taylor, M. R., Sandia National Labs., USA; Jan 1, 1991; 9p; In English; 17th; International Symposium for Testing and Failure Analysis, 11-15 Nov. 1991, Los Angeles, CA, USA

Contract(s)/Grant(s): DE-AC04-76DP-00789

Report No.(s): DE91-018811; SAND-91-0741C; CONF-911115-2; Avail: CASI; A02, Hardcopy; A01, Microfiche

Analysis of an intermittent failure to write the 1 state to a particular memory location at low temperature (-55 C) in a 16K x 1 CMOS SRAM is presented. The failure was found to be due to an open metallization at a metal-to-silicon contact. The root cause of the failure was poor step coverage of the metallization over an oxide step. A variety of failure analysis techniques including dynamic electron beam analysis at low temperature using a Peltier cold stage were employed to study the intermittently failing SRAM. The failure site was located by using capacitive coupling voltage contrast analysis. PSPICE simulation, light emission microscopy, scanning electron microscopy, and focused-ion beam techniques were used to confirm the failure mechanism and location. The write cycle time of the failed IC was abnormally long, but within the allowable tester limit. The vulnerability of other ICs to failure by open metallization in metal-to-silicon contacts is reviewed.

DOE

CMOS; Computer Storage Devices; Failure Analysis; Failure Modes

19920010740 Sandia National Labs., Albuquerque, NM, USA

Light emission microscopy

Soden, J. M., Sandia National Labs., USA; Cole, E. I., Jr., Sandia National Labs., USA; Jan 1, 1992; 16p; In English; IEEE International Reliability Physics Symposium, 30 Mar. - 2 Apr. 1992, San Diego, CA, USA

Contract(s)/Grant(s): DE-AC04-76DP-00789

Report No.(s): DE92-006735; SAND-92-0145C; CONF-920327-2; Avail: CASI; A03, Hardcopy; A01, Microfiche

Light emission microscopy is now currently used in most integrated circuit (IC) failure analysis laboratories. This tutorial is designed to benefit both novice and experienced failure analysts by providing an introduction to light emission microscopy as well as information on new techniques, such as the use of spectral signatures. The use of light emission for accurate identification and spatial localization of physical defects and failure mechanisms is presented. This includes the analysis of defects such as short circuits which do not themselves emit light. The importance of understanding the particular IC design and applying the correct electrical stimulus is stressed. A video tape is used to show light emission from pn junctions, MOS transistors, test structures, and CMOS ICs in static and dynamic electrical stimulus conditions.

DOE

Defects; Detection; Failure Analysis; Failure Modes; Integrated Circuits; Light Emission; Microscopy

19920019571 Oak Ridge National Lab., TN, USA

Assessment of valve actuator motor rotor degradation by Fourier Analysis of current waveform

Kueck, J. D., Carolina Power and Light Co., USA; Criscoe, J. C., Carolina Power and Light Co., USA; Burstein, N. M., Oak Ridge National Lab., USA; Jan 1, 1992; 15p; In English; 54th Annual American Power Conference, 13-15 Apr. 1992, Chicago, IL, USA

Contract(s)/Grant(s): DE-AC05-84OR-21400

Report No.(s): DE92-013233; CONF-920432-11; Avail: CASI; A03, Hardcopy; A01, Microfiche

This paper presents a test report of a motor diagnostic system which uses Fourier Analysis of the motor current waveform to detect broken rotor bars in the motor or defects in the driven equipment. The test was conducted on a valve actuator motor driving a valve actuator which was in turn driving a dynamometer to measure the actuator torque output. The motor was gradually degraded by open circuiting rotor bars. The test confirmed the efficacy of the waveform analysis method for assessing motor rotor degradation and also provided data regarding the change in waveform characteristics as motor rotors are gradually degraded to failure.

DOE

Actuators; Degradation; Electric Current; Electric Motors; Failure Analysis; Failure Modes; Rotors; Valves; Waveforms

19920023251 Westinghouse Savannah River Co., Aiken, SC, USA

System response to relay chatter

Antaki, G. A., Westinghouse Savannah River Co., USA; Radder, J. A., Westinghouse Savannah River Co., USA; Jan 1, 1992; 5p; In English; ASME Pressure Vessel and Piping Conference, 21-25 Jun. 1992, New Orleans, LA, USA

Contract(s)/Grant(s): DE-AC09-89SR-18035

Report No.(s): DE92-013076; WSRC-MS-92-124; CONF-920631-21; Avail: CASI; A01, Hardcopy; A01, Microfiche

An important aspect of the qualification of safety related systems is the assessment of the possibility and consequences of seismic or vibration induced relay chatter. The current rules, contained in ANSI/IEEE C37.98 and the SQUG GIP, consider as seismic induced 'failure' of a relay, a chatter contact in excess of 2 milliseconds. While this rule is clear in defining 'failure' of single relay, the definition of 'failure' becomes more problematic when we consider the alignment of an assembly of relays in

series or parallel, and the effects of chatter on the function of the system in which the relays are mounted. In this paper, we report a method, based on system test and probabilities analysis, used to assess 'failure' by relay chatter in an assembly of relays which control an electric motor.

DOE

Electric Relays; Failure Analysis; Failure Modes; Reactor Safety; Seismology; Vibration

19940024008 Southern Colorado State Coll., Dept. of Electronics Engineering., Pueblo, CO, USA

Investigation of advanced fault insertion and simulator methods *Final Technical Report, Jun. 1984 - Aug. 1986*

Dunn, W. R., Southern Colorado State Coll., USA; Cottrell, D., Southern Colorado State Coll., USA; Jan 1, 1986; 68p; In English

Contract(s)/Grant(s): NCC2-303

Report No.(s): NASA-CR-195241; NAS 1.26:195241; Avail: CASI; A04, Hardcopy; A01, Microfiche

The cooperative agreement partly supported research leading to the open-literature publication cited. Additional efforts under the agreement included research into fault modeling of semiconductor devices. Results of this research are presented in this report which is summarized in the following paragraphs. As a result of the cited research, it appears that semiconductor failure mechanism data is abundant but of little use in developing pin-level device models. Failure mode data on the other hand does exist but is too sparse to be of any statistical use in developing fault models. What is significant in the failure mode data is that, unlike classical logic, MSI and LSI devices do exhibit more than 'stuck-at' and open/short failure modes. Specifically they are dominated by parametric failures and functional anomalies that can include intermittent faults and multiple-pin failures. The report discusses methods of developing composite pin-level models based on extrapolation of semiconductor device failure mechanisms, failure modes, results of temperature stress testing and functional modeling. Limitations of this model particularly with regard to determination of fault detection coverage and latency time measurement are discussed. Indicated research directions are presented.

Author (revised)

Electrical Faults; Failure Analysis; Failure Modes; Large Scale Integration; Medium Scale Integration; Semiconductor Devices

19940027605 Sandia National Labs., Albuquerque, NM, USA

The advent of failure analysis software technology

Henderson, C. L., Sandia National Labs., USA; Barnard, R. D., Sandia National Labs., USA; Jan 1, 1994; 10p; In English; International Reliability Physics Symposium, 11-14 Apr. 1994, San Jose, CA, USA

Contract(s)/Grant(s): DE-AC04-94AL-85000

Report No.(s): DE94-006593; SAND-94-0402C; CONF-940453-2; Avail: CASI; A02, Hardcopy; A01, Microfiche

The increasing complexity of integrated circuits demands that software tools, in addition to hardware tools, be used for successful diagnosis of failure. A series of customizable software tools were developed that organize failure analysis information and provide expert level help to failure analysts to increase their productivity and success.

DOE

Data Base Management Systems; Failure Analysis; Failure Modes; Integrated Circuits; Software Development Tools; Software Engineering

19960051716

Failure modes of valve-regulated lead/acid batteries

Nakamura, K., Japan Storage Battery Co, Ltd, Japan; Shiomi, M.; Takahashi, K.; Tsubota, M.; Journal of Power Sources; March 1996; ISSN 0378-7753; 59, 1-2, pp. 153-157; In English; Copyright; Avail: Issuing Activity

The decline in the cycle-life performance of lead/acid batteries is often caused by deterioration of the positive plates. When batteries are used in electric vehicles, however, the decline in performance is due not only to positive-plate degradation, but also to serious problems with the negative plates. This is because electric-vehicle batteries are used in the form of a pack and their temperature rises excessively (especially during the hot weather) which, in turn, causes decomposition of the lignin additive in the negative plates. Deterioration of the negative plates limits vehicle-running performance even in hybrid electric vehicles (HEV). When batteries are used in this way, charging is achieved during travel via regenerative current and the generator. Thus, the batteries are charged by large currents, and charging is irregular. This causes the accumulation of lead sulfate in the negative plates. Such behavior can be suppressed by increasing the amount of carbon, one of the negative-plate additives. As a consequence, cycle-life performance is improved significantly. On the other hand, in small valve-regulated lead/acid batteries for trickle use, contact between the plates and separators is impaired and this results in a decline in the high-rate discharge performance. This

occurs because transmission of water vapour from the battery container lowers the amount of electrolyte in the separators, which then contract.

Author (EI)

Additives; Degradation; Electric Motor Vehicles; Electrodes; Failure Analysis; Failure Modes; Lead Acid Batteries; Life (Durability); Storage Batteries; Water Vapor

19980053939

Combining functional and structural reasoning for safety analysis of electrical designs

Price, C. J., Univ. of Wales, UK; Snooke, N.; Pugh, D. R.; Hunt, J. E.; Wilson, M. S.; Knowledge Engineering Review; Sep, 1997; ISSN 0269-8889; Volume 12, no. 3, pp. 271-287; In English; Copyright; Avail: Issuing Activity

Increasing complexity of design in automotive electrical systems has been paralleled by increased demands for analysis of the safety and reliability aspects of those designs. Such demands can place a great burden on the engineers charged with carrying out the analysis. This paper describes how the intended functions of a circuit design can be combined with a qualitative model of the electrical circuit that fulfills the functions, and used to analyze the safety of the design. FLAME, an automated failure mode and effects analysis system based on these techniques, is described in detail. FLAME has been developed over several years, and is capable of composing an FMEA report for many different electrical subsystems. The paper also addresses the issue of how the use of functional and structural reasoning can be extended to sneak circuit analysis and fault tree analysis.

Author (EI)

Failure Analysis; Failure Modes; Structural Analysis; Computer Techniques; Network Analysis; Artificial Intelligence; Human-Computer Interface

35

INSTRUMENTATION AND PHOTOGRAPHY

Includes remote sensors; measuring instruments and gauges; detectors; cameras and photographic supplies; and holography. For aerial photography see 43 Earth Resources and Remote Sensing. For related information see also 06 Avionics and Aircraft Instrumentation; and 19 Spacecraft Instrumentation.

19850069733 Massachusetts Inst. of Tech., Dept. of Electrical Engineering and Computer Science., Cambridge, MA, USA

Optimally robust redundancy relations for failure detection in uncertain systems

Lou, X. C., Massachusetts Inst. of Tech., USA; Willsky, A. S., Massachusetts Inst. of Tech., USA; Verghese, G. C., Massachusetts Inst. of Tech., USA; Aug 1, 1984; 32p; In English

Contract(s)/Grant(s): N00014-77-C-0224; AF-AFOSR-0258-82; NGL-22-009-124

Report No.(s): NASA-CR-175533; NAS 1.26:175533; LIDS-TH-1392; Avail: CASI; A03, Hardcopy, Unavail. Microfiche

No abstract.

Failure Analysis; Failure Modes; Models; Reliability Analysis; Robustness (Mathematics)

19900016012 NASA Langley Research Center, Hampton, VA, USA

Failure of the ERBE scanner instrument aboard NOAA 10 spacecraft and results of failure analysis

Miller, J. B., NASA Langley Research Center, USA; Weaver, W. L., NASA Langley Research Center, USA; Kopia, L. P., NASA Langley Research Center, USA; Howerton, C. E., NASA Langley Research Center, USA; Payton, M. G., NASA Langley Research Center, USA; Harris, C. J., ST Systems Corp., USA; May 1, 1990; 27p; In English

Contract(s)/Grant(s): RTOP 665-45-20-01

Report No.(s): NASA-TM-102661; NAS 1.15:102661; Avail: CASI; A03, Hardcopy; A01, Microfiche

The Earth Radiation Budget Experiment (ERBE) scanner instrument on the NOAA 10 spacecraft malfunctioned on May 22, 1989, after more than 4 years of in-flight operation. After the failure, all instrument operational mode commands were tested and the resulting data analyzed. Details of the tests and analysis of output data are discussed therein. The radiometric and housekeeping data appear to be valid. However, the instrument will not correctly execute operational scan mode commands or the preprogrammed calibration sequences. The data indicate the problem is the result of a failure in the internal address decoding circuitry in one of the ROM (read only memory) chips of the instrument computer.

CASI

Chips (Memory Devices); Decoding; Earth Radiation Budget Experiment; Failure Analysis; Failure Modes; Read-Only Memory Devices; Scanners

19910035067

Improve sensor system reliability/performance utilizing failure mode effects and criticality analysis (FMECA) techniques
Ludwig, Dwight L., Eastman Kodak Co., USA; Jan 1, 1989; 8p; In English; 35th; International Instrumentation Symposium, May 1-4, 1989, Orlando, FL, USA; See also A91-19651; Copyright; Avail: Issuing Activity

No abstract.

Component Reliability; Failure Analysis; Failure Modes

19930007812 Auburn Univ., Dept. of Electrical Engineering., AL, USA

Silicon device performance measurements to support temperature range enhancement *Topical Semiannual Report, 7 May 1991 - 6 May 1992*

Bromstead, James, Auburn Univ., USA; Weir, Bennett, Auburn Univ., USA; Johnson, R. Wayne, Auburn Univ., USA; Askew, Ray, Auburn Univ., USA; May 11, 1992; 47p; In English

Contract(s)/Grant(s): NCC3-175

Report No.(s): NASA-CR-191780; NAS 1.26:191780; Avail: CASI; A03, Hardcopy; A01, Microfiche

Testing of the metal oxide semiconductor (MOS)-controlled thyristor (MCT) has uncovered a failure mechanism at elevated temperature. The failure appears to be due to breakdown of the gate oxide. Further testing is underway to verify the failure mode. Higher current level inverters were built to demonstrate 200 C operation of the N-MOSFET's and insulated-gate-bipolar transistors (IGBT's) and for life testing. One MOSFET failed early in testing. The origin of this failure is being studied. No IGBT's have failed. A prototype 28-to-42 V converter was built and is being tested at room temperature. The control loop is being finalized. Temperature stable, high value (10 micro-F) capacitors appear to be the limiting factor in the design at this time. In this application, the efficiency will be lower for the IGBT version due to the large V sub(cesat) (3.5-4 V) compared to the input voltage of 28 V. The MOSFET version should have higher efficiency; however, the MOSFET does not appear to be as robust at 200 C. Both versions are built for comparison.

Author

Control Equipment; Failure Analysis; Failure Modes; Field Effect Transistors; High Temperature; Metal Oxide Semiconductors; Silicon; Temperature Effects; Thyristors

19960003757 Siena Coll., Londonville, NY, USA

G-399 and G178: Lessons learned

Dobeck, Michael, Siena Coll., USA; NASA. Goddard Space Flight Center, The 1995 Shuttle Small Payloads Symposium; Sep 1, 1995, pp. p 133-137; In English; See also N96-13754 02-12

Contract(s)/Grant(s): NAG7-1; Avail: CASI; A01, Hardcopy; A03, Microfiche

This paper outlines the lessons learned implementing Get Away Specials (GAS) payloads G-399 and G-178 with regard to power systems, computer/data logger, structure and working with undergraduates.

Derived from text

Electric Batteries; Failure Analysis; Failure Modes; Get Away Specials (STS); Postflight Analysis; Spaceborne Experiments; Technology Assessment; University Program

36

LASERS AND MASERS

Includes lasing theory, laser pumping techniques, maser amplifiers, laser materials, and the assessment of laser and maser outputs. For cases where the application of the laser or maser is emphasized see also the specific category where the application is treated. For related information see also 76 Solid-State Physics.

19820005548 Defence Research Establishment Valcartier, Research and Development Branch., Valcartier, Quebec, Canada

Surface failure of CO2 laser irradiated glass

Macpherson, R. W., Defence Research Establishment Valcartier, Canada; Anctil, J. C., Defence Research Establishment Valcartier, Canada; Apr 1, 1981; 23p; In English

Report No.(s): AD-A105454; DREV-R-4202/81; Avail: CASI; A03, Hardcopy; A01, Microfiche

The possibility of failure of laser heated glass has important implications in experiments on the thermal shock resistance of materials and in the potential applications of lasers to the machining and heat treating of glass. We describe a method of measuring the damage probability distribution function for laser irradiated glass and develop a model to predict the temperature and stress distributions as a function of time. The experiments and model show that for CO2 laser pulse lengths inferior to 1 ms, the mode

of failure is by fracture under tensile stress induced during cooling after heating a thin layer near the surface beyond the annealing point.

CASI

Carbon Dioxide Lasers; Failure Analysis; Failure Modes; Glass; Irradiation

19980138607

Analysis of VCSEL degradation modes

Herrick, Robert W., California, Univ., Santa Barbara, USA; Cheng, Y. M., California, Univ., Santa Barbara; Beck, James M., California, Univ., Santa Barbara; Petroff, Pierre M., California, Univ., Santa Barbara; Scott, Jeff W., California, Univ., Santa Barbara; Peters, Matthew G., California, Univ., Santa Barbara; Robinson, Gerald D., California, Univ., Santa Barbara; Coldren, Larry A., California, Univ., Santa Barbara; Morgan, Robert A., Honeywell Technology Center, USA; Hibbs-Brenner, Mary K., Honeywell Technology Center, USA; 1996, pp. 123-133; In English

Contract(s)/Grant(s): DAAL01-94-C-3426; Copyright; Avail: AIAA Dispatch

Vertical cavity surface-emitting lasers (VCSELs) have recently made much progress both in improved performance and commercialization. Parallel communication links based on VCSEL arrays are now commercially available. However, little information has been published to date on VCSEL reliability or on what causes VCSEL failures. We describe the VCSEL degradation processes observed in the wide variety of structures we have tested. These include GaAs- and InGaAs-QW VCSELs; top- and bottom-emitting structures; and proton-implanted and etched-pillar VCSELs. We discuss the observation that in most VCSELs examined, defects in the upper mirror can be associated with VCSEL degradation. Laser spectra show a luminescence peak from these mirrors, indicating the presence of minority carriers in the low-bandgap layers of the mirrors. These minority carriers are thought to be at the origin of the defect formation in the p-mirrors. We discuss the possible sources of this minority carrier injection, and present spectra which shed light on the cause of this phenomenon.

Author (AIAA)

Surface Emitting Lasers; Laser Cavities; Thermal Degradation; Failure Modes; Failure Analysis

37

MECHANICAL ENGINEERING

Includes mechanical devices and equipment; machine elements and processes. For cases where the application of a device or the host vehicle is emphasized see also the specific category where the application or vehicle is treated. For robotics see 63 Cybernetics, Artificial Intelligence, and Robotics; and 54 Man/System Technology and Life Support.

19720005767 NASA Marshall Space Flight Center, Huntsville, AL, USA

Saturn component failure rate and failure rate modifiers

Jan 1, 1971; 63p; In English

Report No.(s): NASA-TM-X-64619; Avail: CASI; A04, Hardcopy; A01, Microfiche

Failure mode frequency ratios, environmental adjustment factors, and failure rates for mechanical and electromechanical component families are presented. The failure rates and failure rate modifiers resulted from a series of studies whose purpose was to provide design, tests, reliability, and systems engineers with accurate, up-to-date failure rate information. The results of the studies were achieved through an extensive engineering analysis of the Saturn Program test data and Unsatisfactory Condition Reports (UCR's) and the application of mathematical techniques developed for the studies.

CASI

Failure Analysis; Failure Modes; Saturn 1B Launch Vehicles; Saturn 5 Launch Vehicles

19720006858 McDonnell-Douglas Astronautics Co., Huntington Beach, CA, USA

Failure mechanism of attitude control system valve in chlorine pentafluoride service *Final Technical Report, Jul. 1970 - Mar. 1971*

English, W. D., McDonnell-Douglas Astronautics Co., USA; Samuel, H. D., Jr., McDonnell-Douglas Astronautics Co., USA; Jul 1, 1971; 307p; In English

Contract(s)/Grant(s): F33615-70-C-1760

Report No.(s): AD-729874; AFML-TR-71-94; MDC-G2275; Avail: CASI; A14, Hardcopy; A03, Microfiche

As part of a continuing Air Force effort to develop component technology for high-energy propulsion systems, an attitude control system (ACS) valve was developed elsewhere for use with high-energy storable liquid propellants. This valve performed successfully in most propellants tested; however, it failed by developing excessive leakage when operated in chlorine

pentafluoride. The design and operation of the ACS valve were analyzed for mode of possible failure. The modes studied included overstressing of the closures by closing loads; adhesive wear of the closure surfaces/corrosion of the closures by CPF, and hydrofluoric acid/abrasive wear; corrosive wear; and impact-initiated chemomechanical reactions. Some new equations which relate valve wear to operating and material parameters were developed during the analysis. Tests of some materials were conducted to supply data for certain of the analyses, to test the equations used, and to evaluate some candidate materials. For all of the normal modes of possible failure investigated, it was demonstrated conclusively that the valve is adequately designed to withstand any expected level of load or attack. MDAC has shown by analysis and test that impact-initiated chemomechanical reaction of absorbed water with CPF on the closure surfaces will result in failure of the type observed.

CASI

Chlorine Fluorides; Failure Analysis; Failure Modes; Valves

19720040308

Failure modes, effects and criticality analyses.

Jordan, W. E., NASA Marshall Space Flight Center, USA; Jan 1, 1972; 8p; In English; Annual Reliability and Maintainability Symposium, January 25-27, 1972, San Francisco, CA; See also A72-23972 10-15; Copyright; Avail: Issuing Activity

Failure mode, effects and criticality analyses were developed by NASA as a means of assuring that hardware built for space applications has the desired reliability characteristics. The failure mode and effects analysis is a qualitative reliability technique for systematically analyzing each possible failure mode within a hardware system, and identifying the resulting effect on that system, the mission and personnel. The criticality analysis is a quantitative procedure which ranks the critical failure modes according to their probability of occurrence. This paper describes the failure modes, effects analysis and the criticality analysis. It employs a simple hardware system, not related to the aerospace field, to illustrate the method. It encourages application of this type of analysis to industrial development programs outside the aerospace and defense complex.

AIAA

Failure Analysis; Failure Modes; Spacecraft Reliability

19750029607

System safety as applied to Skylab

Kleinknecht, K. S.; Miller, B. J., NASA Johnson Space Center, USA; Sep 1, 1974; 51p; In English; 25th; International Astronautical Federation, International Astronautical Congress, Sept. 30, 1974-Oct. 5, 1974, Amsterdam, Netherlands; Sponsored by International Astronautical Federation

Report No.(s): IAF PAPER A74-33; Copyright; Avail: Issuing Activity

Procedural and organizational guidelines used in accordance with NASA safety policy for the Skylab missions are outlined. The basic areas examined in the safety program for Skylab were the crew interface, extra-vehicular activity (EVA), energy sources, spacecraft interface, and hardware complexity. Fire prevention was a primary goal, with firefighting as backup. Studies of the vectorcardiogram and sleep monitoring experiments exemplify special efforts to prevent fire and shock. The final fire control study included material review, fire detection capability, and fire extinguishing capability. Contractors had major responsibility for system safety. Failure mode and effects analysis (FMEA) and equipment criticality categories are outlined. Redundancy was provided on systems that were critical to crew survival (category I). The five key checkpoints in Skylab hardware development are explained. Skylab rescue capability was demonstrated by preparations to rescue the Skylab 3 crew after their spacecraft developed attitude control problems.

AIAA

Fire Prevention; Orbital Workshops; Rescue Operations; Safety Management; Skylab Program; Spacecraft Reliability

19830014013 Raytheon Co., Life Cycle Analysis Group., Huntsville, AL, USA

Storage reliability analysis summary report. Volume 5: Optical and electro-optical devices *Final Report, Sep. 1980 - Sep. 1982*

Smith, H. B., Jr., Raytheon Co., USA; Krulac, I. L., Raytheon Co., USA; Sep 1, 1982; 52p; In English; 5volumes

Contract(s)/Grant(s): DAAH01-80-D-0020; DA PROJ. 1W3-63313-D-087

Report No.(s): AD-A122441; AD-E950320; LC-82-2-VOL-5; Avail: CASI; A04, Hardcopy; A01, Microfiche

This document summarizes storage reliability data collected by the US Army Missile Command on optical and electro-optical devices over a period of several years. Sources of data are detailed, major failure modes and mechanisms are listed and discussed.

Non-operational failure rate prediction methodology is given, and conclusions and recommendations for enhancing the storage reliability of devices are drawn from the analysis of the collected data.

DTIC

Electro-Optics; Failure Analysis; Failure Modes; Optical Equipment; Reliability; Storage Stability

19830017815 Westinghouse Electric Corp., Combustion Turbine Systems Div., Concordville, PA, USA

High-reliability gas turbine combined-cycle development program, phase 2, volume 1 *Final Report*

Vetere, A. M., Westinghouse Electric Corp., USA; Mar 1, 1982; 378p; In English; 2volumes; Sponsored by EPRI

Contract(s)/Grant(s): EPRI PROJ. 1176-2

Report No.(s): DE82-901910; EPRI-CS-2206; CONF-8110147; Avail: CASI; A17, Hardcopy; A03, Microfiche

A gas turbine design with sufficient reliability to be considered for baseload service in a combined cycle plant was developed. A conceptual centerline design for gas turbine and accessories, with reliability as the key parameter was generated. The effort and results of interrelated tasks are described. These tasks include: (1) data and RAM methodology update providing a data base necessary for apportionments; predictions, and design efforts utilizing a representative combined cycle plant; (2) RAM and COE analysis including goal allocation, prediction analysis, guidance/support to perform FMEA analysis, combined cycle plant optimization, component life evaluation, and alternate design solutions as a function of COE; (3) centerline combustion turbine engine design including CT auxiliary systems, advanced CT technology development, CT engine performance analysis, subassembly and component design, and integration of a HI-REL CTCC plant.

DOE

Combined Cycle Power Generation; Engine Design; Gas Turbines

19840024758 NASA Marshall Space Flight Center, Huntsville, AL, USA

Materials testing of the IUS techroll seal material

Nichols, R. L., NASA Marshall Space Flight Center, USA; Hall, W. B., Mississippi State Univ.; Jul 1, 1984; 20p; In English

Report No.(s): NASA-TM-86462; NAS 1.15:86462; Avail: CASI; A03, Hardcopy; A01, Microfiche

As a part of the investigation of the control system failure Inertial Upper Stage on IUS-1 flight to position a Tracking and Data Relay Satellite (TDRS) in geosynchronous orbit, the materials utilized in the techroll seal are evaluated for possible failure models. Studies undertaken included effect of temperature on the strength of the system, effect of fatigue on the strength of the system, thermogravimetric analysis, thermomechanical analysis, differential scanning calorimeter analysis, dynamic mechanical analysis, and peel test. The most likely failure mode is excessive temperature in the seal. In addition, the seal material is susceptible to fatigue damage which could be a contributing factor.

M.A.C.

Failure Analysis; Failure Modes; Inertial Upper Stage; Mechanical Properties; Seals (Stoppers); Thermodynamic Properties

19880068064

Failure analysis of precision bearings

Hopple, George, Lockheed Missiles and Space Co., USA; Jan 1, 1987; 8p; In English; ISTFA 1987 - International Symposium for Testing and Failure Analysis: Advanced materials, Nov. 9-13, 1987, Los Angeles, CA, USA; See also A88-55276; Copyright; Avail: Issuing Activity

The present consideration of failure analysis methods for aerospace mechanisms' bearing failures emphasizes disassembly methods for hermetically sealed systems and residual gas analysis. Grease compounds can be freeze-dried for subsequent SEM examination as well as for an IR composition analysis that can identify contaminants. Accounts are given of a procedure for the capture of solid contaminants and wear debris from lubricating oils, and of X-ray microanalysis and IR spectroscopic methods. Illustrative cases of bearing failure from corrosion and lubricant contamination by exogenous liquids and solids are presented.

AIAA

Ball Bearings; Failure Analysis; Failure Modes; Infrared Spectra; Lubricating Oils; Residual Gas

19900004469 NASA Lewis Research Center, Cleveland, OH, USA

An investigation of gear mesh failure prediction techniques

Zakrajsek, James J., NASA Lewis Research Center, USA; Nov 1, 1989; 100p; In English; Prepared in cooperation with Army Aviation Systems Command, Cleveland, OH

Contract(s)/Grant(s): DA PROJ. 1L1-62209-A4-7A; RTOP 505-63-51

Report No.(s): NASA-TM-102340; E-5049; NAS 1.15:102340; AVSCOM-TM-89-C-005; AD-A217844; Avail: CASI; A05, Hardcopy; A02, Microfiche

A study was performed in which several gear failure prediction methods were investigated and applied to experimental data from a gear fatigue test apparatus. The primary objective was to provide a baseline understanding of the prediction methods and to evaluate their diagnostic capabilities. The methods investigated use the signal average in both the time and frequency domain to detect gear failure. Data from eleven gear fatigue tests were recorded at periodic time intervals as the gears were run from initiation to failure. Four major failure modes, consisting of heavy wear, tooth breakage, single pits, and distributed pitting were observed among the failed gears. Results show that the prediction methods were able to detect only those gear failures which involved heavy wear or distributed pitting. None of the methods could predict fatigue cracks, which resulted in tooth breakage, or single pits. It is suspected that the fatigue cracks were not detected because of limitations in data acquisition rather than in methodology. Additionally, the frequency response between the gear shaft and the transducer was found to significantly affect the vibration signal. The specific frequencies affected were filtered out of the signal average prior to application of the methods.

CASI

Failure Analysis; Failure Modes; Fatigue (Materials); Fatigue Tests; Gears; Performance Prediction

19920022256 Oak Ridge National Lab., TN, USA

Motor-operated globe valve performance in a liquid sodium environment

Wood, D. H., Oak Ridge National Lab., USA; Smith, M. S., Oak Ridge National Lab., USA; Drischler, J. D., Oak Ridge National Lab., USA; Jan 1, 1992; 14p; In English; Bi-Annual Nuclear Energy Meeting of the American Nuclear Society, 23-26 Aug. 1992, San Diego, CA, USA

Contract(s)/Grant(s): DE-AC05-84OR-21400

Report No.(s): DE92-014456; CONF-920818-2; Avail: CASI; A03, Hardcopy; A01, Microfiche

This study investigates motor-operated globe valve (MOV) performance in a liquid sodium environment as reported to the Centralized Reliability Data Organization (CREDO) from site representatives at several liquid metal reactors and liquid metal test facilities. The CREDO data base contains engineering histories for 179 motor-operated glove valves. Thirty-nine failures have been documented for these components in over 8.7 million hours of operation. The most common MOV events were anomalies with the limit and torque switches, although human initiated problems were also frequent causes of failures. The failure data suggest that an improved preventive maintenance program with a higher frequency of inspection of the limit and torque switches should increase MOV availability and reliability. The event rate for all failure modes was computed as 4.47 events per 10(exp 8) operating hours by assuming a Poisson distribution of failure over valve operating time. The 5 percent and 95 percent confidence limits based on a chi-squared probability distribution function were computed as 3.36 and 5.83 events per 10(exp 6) operating hours, respectively. The operating performance of these liquid metal MOVs was compared to similar data for MOVs in commercial light water reactors and was found to exhibit similar failure rates.

DOE

Failure; Failure Analysis; Failure Modes; Liquid Metal Fast Breeder Reactors; Liquid Sodium; Statistical Mechanics; Valves

19920023212 NASA Lewis Research Center, Cleveland, OH, USA

Reliability training

Lalli, Vincent R., editor, NASA Lewis Research Center, USA; Malec, Henry A., editor, Siemens Stromberg-Carlson, USA; Dillard, Richard B., Martin Marietta Corp., USA; Wong, Kam L., Hughes Aircraft Co., USA; Barber, Frank J., NASA Lewis Research Center, USA; Barina, Frank J., NASA Lewis Research Center, USA; Jun 1, 1992; 225p; In English

Contract(s)/Grant(s): RTOP 572-10-00

Report No.(s): NASA-RP-1253; E-5456; NAS 1.61:1253; Avail: CASI; A10, Hardcopy; A03, Microfiche

Discussed here is failure physics, the study of how products, hardware, software, and systems fail and what can be done about it. The intent is to impart useful information, to extend the limits of production capability, and to assist in achieving low cost reliable products. A review of reliability for the years 1940 to 2000 is given. Next, a review of mathematics is given as well as a description of what elements contribute to product failures. Basic reliability theory and the disciplines that allow us to control and eliminate failures are elucidated.

CASI

Failure; Failure Analysis; Failure Modes; Maintenance; Reliability; Service Life

19920028679

A surface pitting life model for spur gears. I - Life prediction. II - Failure probability prediction

Blake, J. W., Vanderbilt University, USA; Cheng, H. S., Northwestern University, USA; ASME, Transactions, Journal of Tribology; Oct 1, 1991; ISSN 0742-4787; 113, pp. 712-724; In English

Contract(s)/Grant(s): NSF MSM-84-16365

Report No.(s): ASME PAPER 90-TRIB-59; ASME PAPER 90-TRIB-60; Copyright; Avail: Issuing Activity
No abstract.

Failure Analysis; Failure Modes; Gears; Pitting; Service Life; Surface Cracks

19930012469 Technical Research Centre of Finland, Electrical and Automation Engineering Lab., Espoo, Finland
Analysis of failure and maintenance experiences of motor operated valves in a Finnish nuclear power plant
Moottoritoimisten venttiilien vika- ja korjaustietojen analysointi ydinvoimalaitoksessa

Simola, Kaisa, Technical Research Centre of Finland, Finland; Laakso, Kari, Technical Research Centre of Finland, Finland; Jan 1, 1992; ISSN 1235-0605; 202p; In English; Sponsored by Ministry of Trade and Industry and Nordic Industrial Fund
Report No.(s): VTT-TIED-1322; ISBN 951-38-4054-9; Copyright; Avail: CASI; A10, Hardcopy; A03, Microfiche

Eight years of operating experiences of 104 motor operated closing valves in different safety systems in nuclear power units were analyzed in a systematic way. The qualitative methods used were Failure Mode and Effect Analysis (FMEA) and Maintenance Effects and Criticality Analysis (MECA). These reliability engineering methods are commonly used in the design stage of equipment. The successful application of these methods for analysis and utilization of operating experiences was demonstrated.

ESA

Failure Analysis; Failure Modes; Maintenance; Nuclear Power Plants; Safety Devices; Valves

19930017885 NASA Lewis Research Center, Cleveland, OH, USA

An analysis of gear fault detection methods as applied to pitting fatigue failure data

Zakrajsek, J. J., NASA Lewis Research Center, USA; Townsend, D. P., NASA Lewis Research Center, USA; Decker, H. J., NASA Lewis Research Center, USA; Jan 1, 1993; 12p; In English; 47th; Mechanical Failure Prevention Group, 13-15 Apr. 1993, Virginia Beach, VA, USA; Prepared in cooperation with Army Aviation Systems Command, Cleveland, OH

Contract(s)/Grant(s): RTOP 505-62-10

Report No.(s): NASA-TM-105950; E-7470; NAS 1.15:105950; AVSCOM-TR-92-C-035; Avail: CASI; A03, Hardcopy; A01, Microfiche

The application of gear fault prediction techniques to experimental data is examined. A single mesh spur gear fatigue rig was used to produce naturally occurring faults on a number of test gear sets. Gear tooth surface pitting was the primary failure mode for a majority of the test runs. The damage ranged from moderate pitting on two teeth in one test to spalling on several teeth in another test. Previously published failure prediction techniques were applied to the data as it was acquired to provide a means of monitoring the test and stopping it when a failure was suspected. A newly developed technique along with variations of published methods were also applied to the experimental data. The published methods experienced some success in detecting initial pitting before it progressed to affect the overall root-mean-square (RMS) vibration level. The new technique robustly detected the damage on all of the tests and, in most cases, continued to react to the damage as it spread and increased in severity. Since no single method was able to consistently predict the damage first on all the runs, it was concluded that the best approach to reliably detect pitting damage is to use a combination of detection methods.

Author (revised)

Detection; Failure Analysis; Failure Modes; Fault Detection; Gear Teeth; Pitting; Prediction Analysis Techniques

19930019779 Oak Ridge National Lab., TN, USA

Inservice diagnostic methods for solenoid-operated valves

Kryter, R. C., Oak Ridge National Lab., USA; Jan 1, 1993; 8p; In English; Meeting on Nuclear Plant Instrumentation, Control and Man-Machine Interface Technologies, 18-21 Apr. 1993, Oak Ridge, TN, USA

Contract(s)/Grant(s): DE-AC05-84OR-21400

Report No.(s): DE93-007823; CONF-930401-1; Avail: CASI; A02, Hardcopy; A01, Microfiche

Solenoid-operated valves (SOV's) were studied at Oak Ridge National Laboratory as part of the USNRC Nuclear Plant Aging Research (NPAR) Program. The primary objective of the study was to identify, evaluate, and recommend methods for inspection, surveillance, monitoring, and maintenance of SOV's that can help ensure their operational readiness-that is, their ability to perform required safety functions under all anticipated operating conditions, since failure of one of these small and relatively inexpensive devices could have serious consequences under certain circumstances. An earlier (Phase 1) NPAR program study described SOV failure modes and causes and had identified measurable parameters thought to be linked to the progression of everpresent degradation mechanisms that may ultimately result in functional failure of the valve. Using this earlier work as a guide, the present (Phase 11) study focused on devising and then demonstrating the effectiveness of techniques and equipment with which to measure performance parameters that show promise for detecting the presence and trending the progress of such

degradations before they reach a critical stage. Intrusive techniques requiring the addition of magnetic or acoustic sensors or the application of special test signals were investigated briefly, but major emphasis was placed on the examination of condition-indicating techniques that can be applied with minimal cost and impact on plant operation. Experimental results are presented that demonstrate the technical feasibility and practicality of the monitoring techniques assessed in the study, and recommendations for further work are provided.

DOE

Acoustic Measurement; Control Valves; Cooling Systems; Failure Analysis; Failure Modes; Inspection; Maintenance; Reactor Safety; Safety Devices; Signal Detectors; Surveillance

19960012183 NASA Lewis Research Center, Cleveland, OH, USA

Preloaded joint analysis methodology for space flight systems

Chambers, Jeffrey A., NASA Lewis Research Center, USA; Dec 1, 1995; 29p; In English

Report No.(s): NASA-TM-106943; NAS 1.15:106943; E-9672; NIPS-96-08130; Avail: CASI; A03, Hardcopy; A01, Microfiche

This report contains a compilation of some of the most basic equations governing simple preloaded joint systems and discusses the more common modes of failure associated with such hardware. It is intended to provide the mechanical designer with the tools necessary for designing a basic bolted joint. Although the information presented is intended to aid in the engineering of space flight structures, the fundamentals are equally applicable to other forms of mechanical design.

Author

Aerospace Systems; Bolted Joints; Failure Analysis; Failure Modes; Fasteners

19980148936

A design model for composite joints with multiple fasteners *Modele d'etude de joints de structures composites avec attaches multiples*

Xiong, Y., Inst. for Aerospace Research, Canada; Poon, C., Inst. for Aerospace Research, Canada; 1994; In English

Report No.(s): IAR-AN-80@NRC-32165; Copyright; Avail: Aeroplus Dispatch

An analytical method has been developed for the optimization of the design of mechanically fastened joints in composite structures. The method, which can deal with multiple-hole laminates, consists of three parts: (1) stress analysis, (2) prediction of joint strength and failure mode, and (3) optimization of joint design. For the stress analysis, a complex variational method was used to determine the stress distribution at the fastener holes. The fasteners were modeled as short elastic beams. The joint flexibility was incorporated into an iterative scheme which improved the accuracy of the determination of load transfer by fasteners. The point stress and the quadratic tensor polynomial failure criteria were used for prediction of joint strength and failure mode. A multivariate constrained optimization scheme was used to generate the optimum joint design. Verifications of the analytical predictions against published numerical results and test data were satisfactory. The method has been incorporated into a computer program.

Author (AIAA)

Joints (Junctions); Composite Structures; Stress Analysis; Failure Modes; Design Analysis; Failure Analysis

38

QUALITY ASSURANCE AND RELIABILITY

Includes approaches to, and methods for reliability analysis and control, inspection, maintainability, and standardization.

19760037778

The failure-experience matrix - A useful design tool

Collins, J. A.; Hagan, B. T., Ohio State University, USA; Bratt, H. M., U.S. Army, Air Mobility Research and Development Laboratory, Fort Eustis, USA; Sep 1, 1975; 6p; In English; Design Engineering Technical Conference, Sept. 17-19, 1975, Washington, DC; Sponsored by American Society of Mechanical Engineers

Contract(s)/Grant(s): DAAJ02-73-C-0023; DA TASK 1F162203A11907

Report No.(s): ASME PAPER 75-DET-122; Avail: Issuing Activity

A three-dimensional failure-experience cell matrix is proposed for the purpose of organizing and analyzing existing failure experience data. In the proposed matrix the three axes represent failure modes, elemental mechanical functions, and corrective actions. The usefulness of the failure-experience matrix is demonstrated by investigating over 500 individual failed parts from

U.S. Army helicopters. It is proposed that data from all industry should be gathered and inserted into a central failure-experience matrix and made accessible to all designers.

AIAA

Aircraft Reliability; Failure Analysis; Failure Modes; Matrices (Mathematics); Reliability Engineering

19770018624 Naval Weapons Engineering Support Activity, Washington, DC, USA

Mechanical reliability design evaluation guide status report *Research Report, Jul. - Dec. 1976*

Hall, F. M., Naval Weapons Engineering Support Activity, USA; Ellis, C., Naval Weapons Engineering Support Activity, USA; Skewis, W., Naval Weapons Engineering Support Activity, USA; Dec 1, 1976; 57p; In English

Report No.(s): AD-A035312; NAVWESA-37-76; Avail: CASI; A04, Hardcopy; A01, Microfiche

This interim report reviews the progress at the Naval Weapons Engineering Support Activity in development of a mechanical reliability design guide. Design evaluation techniques under consideration are included, with emphasis on the preparation of a Failure Mode and Effects Analysis (FMEA) Military Standard. Existing FMEA procedures are examined, and a FMEA standard procedure is recommended as a basis for developing improved reliability design evaluation techniques.

CASI

Industrial Plants; Reliability; Systems Analysis

19770067609

Failure modes and effects analysis by matrix method

Barbour, G. L., Aeronutronic Ford Corp., USA; Jan 1, 1977; 6p; In English; Annual Reliability and Maintainability Symposium, January 18-20, 1977, Philadelphia, PA; See also A77-50451 24-38; Copyright; Avail: Issuing Activity

A matrix method for analyzing failure modes and effects has been developed that supplements the standard narrative-tabular and fault tree methods. The new method uses condensed graphic displays of vertical and horizontal lines so that failure effects on the highest system level can be traced down through subsystem and lower equipment levels to the contributing piece part failure modes. In addition to this traceability feature, this approach provides more effective accountability of such items as piece parts, interface connector pins, circuit solder joints, and wiring. This capability becomes invaluable in identifying single point failure modes, that is, single failures that can cause catastrophic loss or major degradation of system performance. The matrix method of analysis can also be used for safety hazard analyses, for determining test and telemetry failure detectability, and for preparing maintenance malfunction location charts.

AIAA

Failure Analysis; Failure Modes; Matrices (Mathematics); System Failures

19770083068 McDonnell-Douglas Corp., Saint Louis, MO, USA

Failure mode and effect analysis airlock, volume 3

Aug 31, 1971; 552p; In English

Contract(s)/Grant(s): NAS9-6555

Report No.(s): NASA-CR-151509; F673-VOL-3-REV; Avail: CASI; A24, Hardcopy, Unavail. Microfiche

No abstract.

Failure Analysis; Failure Modes; Skylab Program; System Failures

19780011578 Missouri Univ., Dept. of Engineering Management., Rolla, MO, USA

A study of failure mode and effect analysis and its role in Air Force program management *Topical*

Potts, F. C., Missouri Univ., USA; Dec 1, 1977; 94p; In English; Sponsored in part by USAF

Report No.(s): AD-A048877; Avail: CASI; A05, Hardcopy; A01, Microfiche

Failure Mode and Effect Analysis (FMEA) is a systematic approach which evaluates a system with respect to its most possible failures. This is accomplished by first making the basic assumption that the system has failed and then hypothesizing specific failure modes, failure causes and failure effects. Also included is a determination of some measure of failure probability and the assignment of a criticality classification. The study examines this process through the formulation of a FMEA on a hypothetical system. The way in which FMEA is currently employed in Air Force defense system procurements is reviewed and the potential benefits of the expanded utilization are explored. The study concludes that the lack of understanding of the basic concepts and the reliability oriented use of FMEA precludes much of its potential benefit to the Air Force Program Manager. Certain benefits are emphasized if the recommended changes to the philosophy surrounding the FMEA process should be adopted.

CASI

Failure Modes; Project Management; Reliability

19790040952

Reliability growth planning to achieve RIW/GMTBF requirements for an airborne radar

Hovis, J. B.; Fieni, D. O., Westinghouse Electric Corp., USA; Jan 1, 1978; 4p; In English; Reliability growth management, testing, and modeling; Seminar, February 27-28, 1978, Washington, DC; See also A79-24956 09-38; Copyright; Avail: Issuing Activity

A reliability engineering approach to meet reliability improvement warranty (RIW) requirements for the airborne fire control radar relies on a comprehensive design and test-analyze-and-fix (TAAF) program. The starting point of the test program is a direct result of the effectiveness of the various reliability tools such as a failure mode and effects analysis (FMEA) and design checklist. The final payoff is seen in the life-cycle costs reflected by the field MTBF. The current field MTBF exceeds the predicted values derived from an inherent MIL-HDBK-217B prediction. The guaranteed MTBF (GMTBF) imposed on the transmitter is not yet in effect. However, the reliability growth performance of the unit seems to indicate that the specified value will be met.

AIAA

Airborne Radar; Avionics; Fire Control; Mtb; Prediction Analysis Techniques; Radar Equipment; Reliability Engineering

19790055885

Testability analysis - Predict it more closely

Smith, G., II, Boeing Wichita Co., USA; Jan 1, 1979; 3p; In English; In: Annual Reliability and Maintainability Symposium, January 23-25, 1979, Washington, DC; See also A79-39876 16-38; Copyright; Avail: Issuing Activity

This paper presents a technique for using a computer-aided design (CAD) test generation program for testability and analysis of digital circuit cards. Although specifically oriented to testability analysis, the technique is also applicable to reliability failure mode and effects analysis (FMEA) and definition of Aerospace Ground Equipment (AGE) test requirements/parameters for a Logistics Engineering Group. CAD test generation is commonly used by design groups, but its application to a testability analysis is unique.

AIAA

Circuit Reliability; Computer Aided Design; Computer Programs; Digital Systems; Fail-Safe Systems; Ground Support Equipment

19800007162 NASA Lewis Research Center, Cleveland, OH, USA

Photovoltaic power system reliability considerations

Lalli, V. R., NASA Lewis Research Center, USA; Jan 1, 1980; 9p; In English; Ann. Reliability and Maintainability Symp., 22-24 Jan. 1980, San Francisco

Contract(s)/Grant(s): DE-AB29-76EI-20370

Report No.(s): NASA-TM-79291; DOE/NASA/20370-79/19; E-235; Avail: CASI; A02, Hardcopy; A01, Microfiche

An example of how modern engineering and safety techniques can be used to assure the reliable and safe operation of photovoltaic power systems is presented. This particular application is for a solar cell power system demonstration project designed to provide electric power requirements for remote villages. The techniques utilized involve a definition of the power system natural and operating environment, use of design criteria and analysis techniques, an awareness of potential problems via the inherent reliability and FMEA methods, and use of fail-safe and planned spare parts engineering philosophy.

J.M.S.

Electric Power Plants; Photovoltaic Conversion; Reliability Engineering; Solar Energy

19800036705

Common-cause failure analysis of multi-failure mode systems

Sambhi, A.; Dhillion, B. S.; Khan, M. R., Ontario Hydro, Canada; Jan 1, 1979; 5p; In English; Modeling and simulation., April 25-27, 1979, Pittsburgh, PA; See also A80-20862 06-66; Copyright; Avail: Issuing Activity

The classical theory is extended to incorporate common cause failures when analyzing a parallel redundant network comprising three-state devices. Formulae for the redundant system reliability, mean-time-to-failure (MTTF), system hazard rate and the variance of time to failure are developed by assuming constant common-cause and other failure rates. The relevant plots are presented to illustrate the theory.

AIAA

Failure Analysis; Failure Modes; Reliability Analysis; System Failures

19800056136

Digital system diagnostics - Design/evaluation

Conley, G. A., IBM Corp., USA; Jan 1, 1980; 5p; In English; Annual Reliability and Maintainability Symposium, January 22-24, 1980, San Francisco, CA; See also A80-40301 16-38; Copyright; Avail: Issuing Activity

The Failure Modes and Effects Analysis (FMEA) process used on a complex digital data system is described. This system incorporated a central processor, man/machine interface channels, microprocessor controlled I/O channels, and fault detection/isolation tools in hardware and software. The process which improved the system's diagnostic capability began with a preliminary diagnostic prediction based on estimates of the effectiveness of hardware and software diagnostic techniques; the FMEA approach was then tailored to allow a detailed prediction based on all possible failure modes in the system. From the FMEA data base, the percentage of the system faults which could be detected and/or isolated was determined. In addition, the areas where faults could not be detected or isolated were identified. The final step, Fault Insertion, verified the system diagnostic capability by simulating faults through the opening and shorting of test points.

AIAA

Complex Systems; Computer Systems Design; Digital Systems; Fail-Safe Systems; Microprocessors; Reliability Engineering

19800056174

Common Cause Failures - A dilemma in perspective

Smith, A. M., General Electric Co., USA; Watson, I. A., U.K. Atomic Energy Authority, UK; Jan 1, 1980; 8p; In English; Annual Reliability and Maintainability Symposium, January 22-24, 1980, San Francisco, CA; See also A80-40301 16-38; Copyright; Avail: Issuing Activity

This paper identifies the broad spectrum of Common Cause Failure (CCF) definitions used by various authors. These definitions, as applied to real aircraft and nuclear reactor failure events, lead to a divergence of interpretation and a resultant confusion that obscures meaningful progression in CCF analysis. A new definition is proposed, explained, and tested against the examples. Technical as well as Administrative Practices are cited as ways to control or eliminate the product defects that lead to CCF.

AIAA

Aircraft Reliability; Failure Analysis; Failure Modes; Nuclear Reactors; System Failures

19810024949 NASA Lewis Research Center, Cleveland, OH, USA

Reliability and quality assurance on the MOD 2 wind system

Mason, W. E. B., NASA Lewis Research Center, USA; Jones, B. G., Boeing Engineering and Construction Co.; Jan 1, 1981; 16p; In English; 5th; Biennial Wind Energy Conf. and Workshop, 5-7 Oct. 1981, Washington, DC, USA; Sponsored by Solar Energy Res. Inst.

Contract(s)/Grant(s): DE-AI01-79ET-20305

Report No.(s): NASA-TM-82717; DOE/NASA/20305-6; E-1015; Avail: CASI; A03, Hardcopy; A01, Microfiche

The Safety, Reliability, and Quality Assurance (R&QA) approach developed for the largest wind turbine generator, the Mod 2, is described. The R&QA approach assures that the machine is not hazardous to the public or to the operating personnel, is operated unattended on a utility grid, demonstrates reliable operation, and helps establish the quality assurance and maintainability requirements for future wind turbine projects. The significant guideline consisted of a failure modes and effects analysis (FMEA) during the design phase, hardware inspections during parts fabrication, and three simple documents to control activities during machine construction and operation.

E.A.K.

Energy Technology; Quality Control; Reliability Analysis; Windpower Utilization; Windpowered Generators

19810032267

A multistate system with several failure modes and cold standby units

Yamashiro, M., Ashikaga Institute of Technology, Japan; Microelectronics and Reliability; Jan 1, 1980; 20, 5, 19, pp. 1980; In English; p. 673-6; Copyright; Avail: Issuing Activity

An analysis is presented for a multistate system with several failure modes, N standby units, and general repair-time distributions. Laplace transforms of the state probability for the system are obtained by using the supplementary variable method.

AIAA

Complex Systems; Failure Analysis; Failure Modes; Systems Engineering

19810039879

Current and future concepts in FMEA

Sevcik, F., Ketron, Inc., USA; Jan 1, 1981; 8p; In English; Annual Reliability and Maintainability Symposium, January 27-29, 1981, Philadelphia, PA; See also A81-24251 09-38; Copyright; Avail: Issuing Activity

The goal of the Failure Modes and Effects Analysis (FMEA) is to anticipate, identify and avoid failures in the operation of a new system while the system is still on the drawing board. The recent occurrence of failures in some new systems in operation has had disastrous effects on many lives. These events prompted the author to evaluate the documented problems and to seek improvements in FMEA procedures and their application. The result was surprising. While a great number of procedures exist, not one single FMEA procedure could be found as an all encompassing document. Each FMEA procedure was different. It is believed that the recent disasters could have possibly been avoided if a good FMEA procedure had been applied during development. A simple, complete FMEA procedure is proposed.

AIAA

Failure Analysis; Failure Modes; Performance Prediction; Reliability Analysis; Reliability Engineering; System Failures

19810058863

Maintainability applications using the matrix FMEA technique

Herrin, S. A., ESL, Inc., USA; IEEE Transactions on Reliability; Aug 1, 1981; R-30, pp. Aug. 198; In English; p. 212-217; Copyright; Avail: Issuing Activity

The Matrix Method of Failure Modes and Effects Analysis (FMEA) provides an organized and traceable analysis from the piece-part failure-mode through all indenture levels to system-level failure effects. This paper describes a methodology for reversing the buildup process for maintainability analysis. The output of this reverse process identifies each system-failure effect individually and the related indentured, lower-level composition of contributing sources of failure. The results of this technique provide source data for identifying different levels of ambiguity for fault isolation, evaluating test point adequacy, formulating replacement level criteria, developing maintenance diagnostic charts and procedures, validating maintenance concepts, and segregating most-probable faults for spare parts requirements.

AIAA

Airborne Equipment; Electronic Equipment Tests; Failure Analysis; Failure Modes; Maintainability; System Failures

19820011676 NASA Lewis Research Center, Cleveland, OH, USA

Experience with modified aerospace reliability and quality assurance method for wind turbines

Klein, W. E., NASA Lewis Research Center, USA; Jan 1, 1982; 11p; In English; 9th; Ann. Engr. Conf. on Reliability, 16-18 Jun. 1982, Hershey, PA, USA

Contract(s)/Grant(s): DE-AI01-76ET-20320

Report No.(s): NASA-TM-82803; DOE/NASA/20320-38; E-1142; Avail: CASI; A03, Hardcopy; A01, Microfiche

The SR&QA approach assures that the machine is not hazardous to the public or operating personnel, can operate unattended on a utility grid, demonstrates reliability operation, and helps establish the quality assurance and maintainability requirements for future wind turbine projects. The approach consisted of modified failure modes and effects analysis (FMEA) during the design phase, minimal hardware inspection during parts fabrication, and three simple documents to control activities during machine construction and operation. Five years experience shows that this low cost approach works well enough that it should be considered by others for similar projects.

T.M.

Assurance; Quality Control; Reliability; Safety; Turbogenerators; Windpowered Generators

19830011918 Electricite de France, Div. des Etudes et Recherches., Clamart, France

A systems safety-reliability analysis method: The combined failures method *UNE METHODE D'ANALYSE DE LA FIABILITE ET DE LA SECURITE DES SYSTEMES: LA METHODE DES COMBINAISONS DE PANNES*

Villemeur, A., Electricite de France, France; ESA Reliability and Maintainability; Sep 1, 1982, pp. p 71-79; In French; See also N83-20178 10-38; Avail: CASI; A02, Hardcopy; A06, Microfiche

The use of failure modes and effects analysis (FMEA) generally shows only simple failures and should be completed by studying the combinations of failures which result in undesirable events. The combined failures method (MCP), initially used to analyze the reliability and safety of the Concorde and Airbus aircraft, is described and is recommended for use following FMEA.

The principles of MCP are reviewed and illustrated in the analysis of a very simple system. Theoretical fundamental principles are then developed and an algorithm is proposed for using MCP to analyze a group of complex systems.

Transl. by A.R.H.

Complex Systems; Failure Modes; Reliability Analysis; Safety; Systems Analysis

19830014342 Los Alamos Scientific Lab., NM, USA

The FRAC (Failure Rate Analysis Code): A computer program for analysis of variance of failure rates. An application user's guide

Beckman, R. J., Los Alamos Scientific Lab., USA; McInteer, C. R., Los Alamos Scientific Lab., USA; Mar 1, 1982; 54p; In English

Contract(s)/Grant(s): W-7405-ENG-36

Report No.(s): DE82-012017; NUREG/CR-2434; Avail: CASI; A04, Hardcopy; A01, Microfiche

Probabilistic risk assessments (PRAs) require estimates of the failure rates of various components whose failure modes appear in the event and fault trees used to quantify accident sequences. In the nuclear industry, the Nuclear Plant Reliability Data System (NPRDS) and the In-Plant Reliability Data System (IPRDS), among others, were designed for this purpose. An important characteristic of such data bases is the selection and identification of numerous factors used to classify each component that is reported and the subsequent failures of each component. However, the presence of such factors often complicates the analysis of reliability data in the sense that it is inappropriate to group (that is, pool) data for those combinations of factors that yield significantly different failure rate values. These types of data can be analyzed by analysis of variance. FRAC (Failure Rate Analysis Code) is a computer code that performs an analysis of variance of failure rates. In addition, FRAC provides failure rate estimates.

DOE

Component Reliability; Failure Analysis; Failure Modes; Risk

19830026071 Bendix Corp., Kansas City, MO, USA

Component reliability as experienced by manufacture of electronic assemblies

Clements, D. W., Bendix Corp., USA; Feb 1, 1983; 8p; In English; 33rd; Electron. Components Conf., 16 May 1983, Orlando, FL, USA

Contract(s)/Grant(s): DE-AC04-76DP-00613

Report No.(s): DE83-011552; BDX-613-2872; CONF-830517-5; Avail: CASI; A02, Hardcopy; A01, Microfiche

The component definition, procurement, and inspection procedures used by a manufacturer of very high reliability electronic products are reviewed. The performance of the components during the product manufacturing and inspection process is examined to determine the resultant component failure rate and failure modes. The failure rate for each component type and the most common failure mode for each component type are identified. This information then is reviewed to determine if there are any basic deficiencies not any component type and, if so, what recommendations or changes can be made to improve component reliability.

DOE

Component Reliability; Electronic Equipment; Failure Analysis; Failure Modes

19840010395 Societe Nationale Industrielle Aerospatiale, Cannes, France

Failure mode prediction analysis using the Reliability Information Software (RIF) *L'analyse Previsionelle Des Modes De Defaillance A L'aide D'un Progiciel Denomme Systeme D'informations Fiabilite*

Demollerat, T., Societe Nationale Industrielle Aerospatiale, USA; Courtin, J. P., Societe d'Etudes des Systemes d'Automation; ESA First European Space Mech. and Tribology Symp.; Dec 1, 1983, pp. p 73-77; In French; See also N84-18454 09-31; Avail: CASI; A01, Hardcopy; A03, Microfiche

The Reliability Information Software (RIF) for spacecraft component failure prediction is outlined. The RIF describes failure modes, failure effects, cause of failure, and solution. It provides a reliability estimate on a component, subsystem or system level. It uses an IBM 370 computer.

CASI

Failure Analysis; Failure Modes; Prediction Analysis Techniques; Spacecraft Components

19840063709

Fault tree analysis, taking into account causes of common mode failures

Stecher, K., Siemens AG, Germany; Siemens Forschungs- und Entwicklungsberichte; Jan 1, 1984; ISSN 0370-9736; 13, 4, 19; 8p; In English; Copyright; Avail: Issuing Activity

In evaluating fault trees using Boolean algebra and system function, subsystems can only be separated out if there are no failures of multiple-system components attributable to a common cause; i.e., so-called common-mode failures. For systems with distributed common modes, the effort required for this evaluation increases exponentially with the number of design components. This problem has been solved by means of a method in which the reliability data for the simple components are inserted on the lowest possible level of evaluation, whereas the data for the common modes are substituted at the top of the fault tree. The method described provides the basis for a computer program.

AIAA

Complex Systems; Failure Analysis; Failure Modes; Fault Trees; Reliability Analysis

19850023205 Hughes Aircraft Co., Ground Systems Group., Fullerton, CA, USA

Automated FMEA (Failure Modes and Effects Analysis) techniques *Final Report, Apr. 1982 - Mar. 1984*

Goddard, P. L., Hughes Aircraft Co., USA; Davis, R., Hughes Aircraft Co., USA; Dec 1, 1984; 172p; In English

Contract(s)/Grant(s): F30602-82-C-0072

Report No.(s): AD-A154161; RADC-TR-84-244; Avail: CASI; A08, Hardcopy; A02, Microfiche

The techniques traditionally in use for Failure Modes and Effects Analysis (FMEA) have been fragmented in approach and not fully automated. These limitations can result in FMEA's being performed which are inconsistent in quality and approach. The Advanced Matrix FMEA Technique is presented as a standardized FMEA technique, and the automation of this technique is discussed. Additionally, the results of research into component failure modes to support FMEA are presented. The purpose of the study was to determine the feasibility of standardizing and automating FMEA techniques for electronics and to develop such techniques. FMEA is a bottom-up, inductive, failure analysis technique. This analysis, which is normally performed by reliability engineers, is used to support multiple disciplines. The analysis output supports reliability, maintainability, testability, logistics, and safety activities. The analysis starts with a single point, low-level failure and proceeds upward through the hardware under analysis to define the failure effect at each level.

DTIC

Automatic Control; Failure Analysis; Failure Modes

19850056115

Classification of Characteristics - Rich source of test requirements

Pope, M.; Dirnbach, P. H., Rockwell International Corp., USA; Jan 1, 1984; 6p; In English; 8th; Aerospace Testing Seminar, March 21-23, 1984, Los Angeles, CA; Sponsored by Insititue of Environmental Sciences and Aerospace Corp.; See also A85-38251 17-14; Avail: Issuing Activity

Test requirements are found in connection with three different situations. Thus, a contract may contain test requirements, or interpretations of test requirements. Another situation requiring the conduction of tests is related to design or development processes, while a third situation is produced by the need to conduct failure assessment studies. An analytical technique called 'Classification of Characteristics' provides the means for a detailed and highly graphic assessment of possible failure modes. This technique applies to design characteristics which affect personnel safety or mission reliability. The basic steps for implementing Classification of Characteristics include an identification of the component or system failure modes and their causes by a fault tree analysis, and a classification of the failure modes as critical or major. Attention is also given to the identification of all design characteristics related to possible failure modes, the coordination of the required action with certain organizations, and aspects of documentation.

AIAA

Classifications; Failure Analysis; Failure Modes; Production Planning; User Requirements

19860018000 Carnegie-Mellon Univ., Dept. of Mechanical Engineering., Pittsburgh, PA, USA

Computer-automated failure prediction in mechanical systems under dynamic loading *Monthly Report*

Desilva, C. W., Carnegie-Mellon Univ., USA; Shock and Vibration Information Center(Defense), The Shock and Vibration Digest, Volume 17, No. 8.; Aug 1, 1985, pp. p 3-12; In English; See also N86-27471 18-31; Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375

A computer-automated system for failure prediction in mechanical systems having many components that are functionally and physically interconnected is described. This system consists of three subsystem modules: component failure models developed from available data and procedures; reliability model for the overall mechanical system, developed using functional interrelations and failure models of individual components; and failure diagnostic and model-parameter updating system. The

general structures of these three modules and their role in obtaining accurate predictions for time and mode of next failure are discussed. Pertinent background information is provided.

CASI

Computer Techniques; Dynamic Loads; Failure Analysis; Failure Modes; Mechanical Devices; Prediction Analysis Techniques

19860037644

The automated, advanced matrix FMEA technique

Goddard, P. L.; Davis, R. W., Hughes Aircraft Co., USA; Jan 1, 1985; 5p; In English; See also A86-22376; Copyright; Avail: Issuing Activity

It is pointed out that the Failure Modes and Effects Analysis (FMEA) is one of the most effective design analysis techniques used in reliability engineering. Thus, a properly performed FMEA can be used to support a wide range of analyses and disciplines. However, FMEA is expensive to perform, and it requires the use of one or more highly skilled analysts. In addition, MIL-STD-1629A, representing tabular FMEA documentation, is not organized in a way which would permit the maximum effective use of all analysis results. The present paper is concerned with the Advanced Matrix Technique which provides a solution to several of the major problems with FMEA. The Advanced Matrix Technique was developed as part of a study of automated FMEA techniques. Attention is given to the objectives of the Advanced Matrix Technique, aspects of technical structure, technical phasing, and the Failure Effects and Data Synthesis computer program, which was developed to automate the Advanced Matrix FMEA technique.

AIAA

Aircraft Reliability; Failure Modes; Matrix Methods; Reliability Engineering

19860037657

Improved methods for computerized FMEA

Lind, J. A., Ford Aerospace and Communications Corp., USA; Jan 1, 1985; 4p; In English; See also A86-22376; Copyright; Avail: Issuing Activity

Conventional narrative or tabular FMEAs are formatted to either allow tracing from a design element to its effects or from an effect to the design elements causing that effect. The tabular FMEAs generally do not provide full traceability between the effects and the failure modes of a design. The matrix FMEA technique was introduced to provide full traceability between effects and design element failure modes by use of a cross referencing matrix. For small FMEAs the matrix is adequate, but for FMEAs with a large number of effects, failure modes and/or design elements, the matrix becomes inadequate. A tabular FMEA format has been developed that overcomes the problems of the matrix FMEA approach for large FMEAs and also provides additional capability for addressing causes, preventive measures, criticality, and other data. A computerized system for the preparation of FMEAs, FMECAs, and Product Design FMEAs using this tabular format is described.

AIAA

Failure Analysis; Failure Modes; Matrix Methods

19860037658

Hardware/software FMEA applied to airplane safety

Van Baal, J. B. J., Nationaal Lucht- en Ruimtevaartlaboratorium, Netherlands; Jan 1, 1985; 6p; In English; See also A86-22376; Copyright; Avail: Issuing Activity

Recent changes in the nature of airplane systems have created the need for a systematical and analytical methodology for system safety assessment. Such a methodology is briefly explained. A try-out on a software controlled digital avionics system is described. Special attention is paid to the analysis of the software components of the system. From this work it is concluded that the same methodology can be applied to both software and hardware. Two conditions that have to be met to perform a successful hardware/software safety assessment are described.

AIAA

Aircraft Safety; Avionics; Computer Programs; Failure Analysis; Failure Modes; Hardware

19860037673

Economical fault isolation analysis

Garfield, J., Gould, Inc., USA; Bazovsky, I., Jr., Igor Bazovsky Associates, Inc., USA; Jan 1, 1985; 5p; In English; See also A86-22376; Copyright; Avail: Issuing Activity

A methodology for performing a cost-effective fault isolation analysis based on a limited amount of design information, is described. The methodology was developed by tailoring the failure analysis to the specific conditions imposed with respect to

system partitioning; fault string limiting; diagnostic sequence optimization and percentage of failure occurrence tabulation. The tailoring process applied to failure analysis in the case of MIL-STD-1629 A, MIL-STD-1543 A (USAF) for shop replaceable units (SRUs) is described as an example.

AIAA

Economic Factors; Failure Analysis; Failure Modes

19870028160

Integration of Sneak Circuit Analysis with FMEA

Jackson, T., TRW, Inc., USA; Jan 1, 1986; 7p; In English; See also A87-15401; Copyright; Avail: Issuing Activity

If the practicality of Sneak Circuit Analysis (SCA) is to be realized in commercial and military projects, a way must be found to make it more cost-effective. SCA is useful in uncovering latent circuit conditions which result in unplanned modes of operation. However, the conventional method of performing the analysis is labor-intensive, involving numerous hypothesized fault conditions and the building of topological network trees. As a result, analyzing even moderately sized systems is very expensive. Functional Sneak Circuit Analysis (FSCA), a manual analysis technique that augments design validation tasks and Failure Modes and Effects Analysis (FMEA), is introduced. The detection of latent circuit conditions is divided into two independent tasks in FSCA, and all of the strengths of conventional SCA are preserved, at much less cost. Aspects of FSCA are compared to corresponding conventional practices where applicable. Practical application is illustrated by two examples.

AIAA

Failure Modes; Network Analysis; Sneak Circuit Analysis; System Failures

19870034061

A methodology for failure modes effects and criticality analysis (FMECA) *Methodologie des analyses de modes de defaillance de leurs effets et de leur criticite - /AMDEC/*

JARROUSSE, Alcatel Thomson Espace, France; Schietecatte, M., Matra, France; Jan 1, 1986; 30p; In French; See also A87-21326; Copyright; Avail: Issuing Activity

Details of the FMECA employed by ESA during the design phase of space missions to identify dangers for the mission, personnel and of failure propagation are discussed. FMECA design optimization tasks such as the definition of critical failure modes and the means to identify them, risk reduction and the generation of failure trees are outlined. The tasks identify the telemetry necessary for ground control to detect, identify, correct and/or control component failures before they propagate. Emphasis is placed on the thoroughness of documentation of each potential defect.

AIAA

Astrionics; Failure Analysis; Failure Modes; Reliability Analysis; System Failures

19870044265

Problems with failure modes and effects analysis for digital avionics

Hecht, Herbert, SoHar, Inc., USA; Jan 1, 1986; 6p; In English; See also A87-31451; Copyright; Avail: Issuing Activity

The provisions of the MIL-STD-1629A standard for Failure Modes and Effects Analysis (FMEA) are discussed with respect to their applicability to digital avionics equipment, and problem areas are highlighted. It is noted that current practices usually circumvent rather than correct deficiencies, and that they introduce duplication and uncertainty into the application of FMEA-related information in the design of digital equipment. An approach in which an individual FMEA is restricted to one hierarchical level, and in which a built-in feedback mechanism identifies and corrects its own deficiencies by identifying FMEA problem areas as part of the normal reporting system, is proposed.

AIAA

Avionics; Digital Electronics; Failure Analysis; Failure Modes; Mission Planning

19870052625

The alternative to 'launch on hunch'

Lerner, Eric J.; Aerospace America; May 1, 1987; ISSN 0740-722X; 25, pp. 40; In English; 41, 44; Copyright; Avail: Issuing Activity

An evaluation is made of the operational consequences of a change in NASA launch decision-making policy from the nonquantitative Failure Modes and Effects Analysis (FMEA) method to the nuclear industry's fully quantitative Probability Risk Assessment (PRA). In FMEA, each component or subcomponent is analyzed and the ways it can fail are determined with a view to their effect on subsystems, systems, and entire vehicles. In PRA, a possible failure mode for the entire system is identified, and

the possible ways in which this may occur are listed with a view to contributory faults and chains of faults whose analyses ultimately arrive at a basis in some component failure or human error.

AIAA

Decision Making; NASA Programs; Risk; Spacecraft Launching

19880033270

The case for component and board pretesting

White, Max A., Jr., Martin Marietta Corp., USA; Jan 1, 1987; 11p; In English; Electronic materials and processes, June 23-25, 1987, Santa Clara, CA, USA; Sponsored by SAMPE; See also A88-20491; Copyright; Avail: Issuing Activity

Component testing prior to the assembly process has become a necessity in emerging high-density, multilayer printed circuit assembly component and multilayer printed circuit board technologies. The results of a complete analysis for expected and required failure rates of components and printed circuit assemblies are presented in tabular form, and a testing program approach for semiconductors is examined that encompasses failure rate data analysis, component failure analysis, and destructive physical analysis results. A testing system which integrates available data is recommended.

AIAA

Electronic Equipment Tests; Failure Analysis; Failure Modes; Printed Circuits; Statistical Analysis

19880055633

Assigning a numerical value to the beta factor common cause evaluation

Humphreys, R. A., Rolls-Royce and Associates, Ltd., UK; Jan 1, 1987; 8p; In English; Reliability '87, Apr. 14-16, 1987, Birmingham; Sponsored by U. K. Atomic Energy Authority, Institute of Quality Assurance, Royal Aeronautical Society.; See also A88-42851; Avail: Issuing Activity

The concept of the beta factor modeling of common cause failures is briefly reviewed, and a model is presented for estimating the beta factor from the attributes of a given system. Although the model has been developed for use with electronic and electrical systems characterized by full or partial redundancy, it can be applied more generally, provided that values can be allocated against each of the subfactors. The model is intended as an aid to both assessment and design.

AIAA

Beta Factor; Failure Analysis; Failure Modes; Mathematical Models

19880056146

Efficient analysis for FMEA

Marriott, Douglas, Illinois, University, USA; Bednarz, Steven; Jan 1, 1988; 6p; In English; Annual Reliability and Maintainability Symposium, Jan. 26-28, 1988, Los Angeles, CA, USA; See also A88-43326; Copyright; Avail: Issuing Activity

The use of minimal knowledge in mechanical systems reliability assessment is considered. The design analysis of the US space shuttle solid rocket booster joint is used as an example of this approach and an approximate shell analysis of the joint is presented. Approximate analysis methods, it is argued, are well suited to the breadth-first reliability assessment required early in the design process for failure prevention. Implications of this approach are discussed for other engineering failures and the mechanical design process in general.

AIAA

Design Analysis; Reliability Analysis; Space Shuttle Boosters; Spacecraft Reliability

19880068072

A brief assessment of failure detection methods

Panossian, Hagop, Rockwell International Corp., USA; Jan 1, 1987; 6p; In English; ISTFA 1987 - International Symposium for Testing and Failure Analysis: Microelectronics, Nov. 9-13, 1987, Los Angeles, CA, USA; See also A88-55296; Copyright; Avail: Issuing Activity

A brief review of analytical and hardware failure detection techniques will be presented and discussed herein. Various features, advantages, and disadvantages of each method will be pointed out and its practicality and ease of implementation will be underlined. The algorithms involved in major failure detection and isolation schemes will be presented and briefly discussed. References will be cited for further information regarding the various techniques and their implementation procedures.

AIAA

Electronic Equipment Tests; Failure Analysis; Failure Modes; Fault Tolerance; Feedback Control; Test Equipment

19890008517 Ohio State Univ., Columbus, OH, USA

Effects of assuming independent component failure times, if they are actually dependent, in a series system *Final Report, 1 Sep. 1982 - 31 Dec. 1987*

Moeschberger, Melvin L., Ohio State Univ., USA; Klein, John P., Ohio State Univ., USA; May 1, 1988; 295p; In English

Contract(s)/Grant(s): AF-AFOSR-0307-82; AF PROJ. 2304

Report No.(s): AD-A200892; AFOSR-88-1001TR; Avail: CASI; A13, Hardcopy; A03, Microfiche

The overall objective of this proposal is to develop improved estimation techniques for us in reliability studies when there are competing failure modes or competing causes of failure associated with a single failure mode in data from series systems. Such improved nonparametric estimators of the component failure distribution will be accomplished by incorporating some dependence structure between the potential component failure times. The first specific aim is to investigate techniques which identify departures from independence, based on data collected from series systems, by making some restrictive assumptions about the structure of the system, and obtain modified nonparametric estimators which incorporate some restrictive assumptions about the structure of the system. The second aim will be to develop improved nonparametric estimators of component lifetimes by obtaining modifications of the product limit estimator which incorporate some parametric information and by studying the robustness of these estimators to misspecification of the parametric model. Competing risk analyses have been performed in the past and will continue to be performed in the future. This study will provide the user of such techniques with an alternative to the usual approach of assuming independent risks, an assumption which most of the methods currently in use assume.

DTIC

Component Reliability; Estimates; Failure Analysis; Failure Modes; Risk; System Failures

19890059100

Reliability models for mechanical equipment

Nelson, Jimmie J.; Bowman, James; Perkins, Garry; Wannamaker, Alonzo, Eagle Technology, Inc., USA; Raze, James D., U.S. Army, Belvoir Research, Development and Engineering Center, USA; Jan 1, 1989; 8p; In English; Annual Reliability and Maintainability Symposium, Jan. 24-26, 1989, Atlanta, GA, USA; See also A89-46451 20-38; Copyright; Avail: Issuing Activity

A description is given of a reliability prediction technique for mechanical equipment that will enable the designer to qualify the effects of varying design and operational constraints on a mechanical component's failure rate. The designer can then implement design changes to improve the systems reliability before fabrication begins. In addition, reliability information identified by this procedure during design can be utilized for efficient and effective utilization of testing resources. Example models for compressors are addressed.

AIAA

Failure Analysis; Failure Modes; Mechanical Devices; Prediction Analysis Techniques; Structural Reliability

19900002718 NASA Lewis Research Center, Cleveland, OH, USA

Model OA wind turbine generator FMEA *Final Report*

Klein, William E., NASA Plum Brook Reactor Facility, USA; Lalli, Vincent R., NASA Lewis Research Center, USA; Oct 1, 1989; 8p; In English; 1990 Annual Reliability and Maintainability Symposium, 23-25 Jan. 1990, Los Angeles, CA, USA; Sponsored by ASME

Contract(s)/Grant(s): DE-AB29-79ET-20370

Report No.(s): NASA-TM-102378; E-5117; NAS 1.15:102378; DOE/NASA/20370-23; Avail: CASI; A02, Hardcopy; A01, Microfiche

The results of Failure Modes and Effects Analysis (FMEA) conducted for the Wind Turbine Generators are presented. The FMEA was performed for the functional modes of each system, subsystem, or component. The single-point failures were eliminated for most of the systems. The blade system was the only exception. The qualitative probability of a blade separating was estimated at level D-remote. Many changes were made to the hardware as a result of this analysis. The most significant change was the addition of the safety system. Operational experience and need to improve machine availability have resulted in subsequent changes to the various systems which are also reflected in this FMEA.

CASI

Failure Analysis; Failure Modes; Turbine Blades; Wind Turbines

19900014436 Pratt and Whitney Aircraft, Materials Engineering and Technology Labs., West Palm Beach, FL, USA

Failure analysis handbook *Final Report, 1 Sep. 1986 - 29 Apr. 1989*

Walker, C. R., Pratt and Whitney Aircraft, USA; Starr, K. K., Pratt and Whitney Aircraft, USA; Aug 18, 1989; 759p; In English
Contract(s)/Grant(s): F33615-86-C-5007; AF PROJ. 2418

Report No.(s): AD-A219747; PW/ED/FR-20820; WRDC-TR-89-4060; Avail: CASI; A99, Hardcopy; A06, Microfiche

Aircraft service failures of any type, from a simple rivet failure to complete engine failure, have the potential to result in loss of the aircraft and personnel. Accurate determination of the cause of the failure may yield information that will prevent similar future failures from occurring. It is helpful for the investigator to have a data base of known failure modes to draw from in forming conclusions. The objective of this program was to update and augment the two primary Air Force failure analysis handbooks, Electron Fractography Handbook and SEM/TEM Fractography Handbook, published in 1965 and 1975, respectively, with a new Failure Analysis Handbook. The new handbook includes fractography of alloys and conditions not previously covered in other handbooks. The handbook also is a guide for procedures and lists other sources of information.

DTIC

Aircraft Equipment; Electron Optics; Failure Analysis; Failure Modes; Fatigue (Materials); Fractography; Fracture Mechanics; Handbooks

19900053521

Application of Taguchi methods to composite case problems

Biagioni, J. R., Jr., Aerojet, Propulsion Div., Sacramento, USA; Jul 1, 1990; 21p; In English

Contract(s)/Grant(s): F04704-86-C-0092

Report No.(s): AIAA PAPER 90-1669; Copyright; Avail: Issuing Activity

This paper describes a failure-modes investigation approach that successfully solved a series of failures that were occurring in rocket motor cases during manufacture. Because of the materials used in fabricating the case, it was assumed that moisture was the principal cause of the observed failure modes; however, a combination of factors was found to be at fault, primarily through the successful incorporation of the experimental design and analysis technique offered by Taguchi methods. This technique uses orthogonal arrays, analysis of variance, and signal-to-noise analysis in a manner that permitted the successful completion of this failure investigation with only 63 designed experiments instead of the more than 13,000 that would have been required using full factorial arrays. The result: no recurrence of the failure modes that were causing a 12-percent loss rate during case manufacture and the avoidance of major capital expenditures considered necessary to solve the problems.

AIAA

Composite Structures; Failure Analysis; Failure Modes; Moisture Content; Pressure Vessel Design; Rocket Engine Cases

19910006253 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, USA

An improved approach for flight readiness assessment

Moore, N. R., Jet Propulsion Lab., California Inst. of Tech., USA; Ebbeler, D. H., Jet Propulsion Lab., California Inst. of Tech., USA; Creager, M., Jet Propulsion Lab., California Inst. of Tech., USA; Oct 30, 1990; 17p; In English

Contract(s)/Grant(s): NAS7-918

Report No.(s): NASA-CR-187809; JPL-PUBL-90-46; NAS 1.26:187809; Avail: CASI; A03, Hardcopy; A01, Microfiche

An improved methodology for quantitatively evaluating failure risk for a spaceflight system in order to assess flight readiness is presented. This methodology is of particular value when information relevant to failure prediction, including test experience and knowledge of parameters used in engineering analyses of failure phenomena, is limited. In this approach, engineering analysis models that characterize specific failure modes based on the physics and mechanics of the failure phenomena are used in a prescribed probabilistic structure to generate a failure probability distribution that is modified by test and flight experience in a Bayesian statistical procedure. The probabilistic structure and statistical methodology are generally applicable to any failure mode for which quantitative engineering analysis can be employed to characterize the failure phenomenon and are particularly well suited for use under the constraints on information availability that are typical of such spaceflight systems as the Space Shuttle and planetary spacecraft.

CASI

Failure Analysis; Failure Modes; Probability Theory; Reliability; Space Flight; Spacecraft Design; Statistical Analysis

19910009662 Middle Tennessee State Univ., Dept. of Mathematics and Statistics., Murfreesboro, TN, USA

Is it possible to identify a trend in problem/failure data

Church, Curtis K., Middle Tennessee State Univ., USA; Alabama Univ., Research Reports: 1990 NASA(ASEE Summer Faculty Fellowship Program; Oct 1, 1990, pp. 5 p; In English; See also N91-18967 10-99

Contract(s)/Grant(s): NGT-01-002-099; Avail: CASI; A01, Hardcopy; A03, Microfiche

One of the major obstacles in identifying and interpreting a trend is the small number of data points. Future trending reports will begin with 1983 data. As the problem/failure data are aggregated by year, there are just seven observations (1983 to 1989) for the 1990 reports. Any statistical inferences with a small amount of data will have a large degree of uncertainty. Consequently,

a regression technique approach to identify a trend is limited. Though trend determination by failure mode may be unrealistic, the data may be explored for consistency or stability and the failure rate investigated. Various alternative data analysis procedures are briefly discussed. Techniques that could be used to explore problem/failure data by failure mode are addressed. The data used are taken from Section One, Space Shuttle Main Engine, of the Calspan Quarterly Report dated April 2, 1990.

CASI

Failure Analysis; Failure Modes; Prediction Analysis Techniques; Space Shuttle Main Engine; Statistical Analysis; Trend Analysis

19910023051 Selenia Spazio S.p.A., Rome, Italy

Results and considerations on failure investigations of components used for space equipment

Tommaso, G., Selenia Spazio S.p.A., Italy; ESA, ESA Electronic Components Conference; Mar 1, 1991, pp. p 475-480; In English; See also N91-32291 24-33; Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

The major findings and considerations derived from failure investigations of components used by Selenia Spazio during manufacturing of space equipment (flight and qualification models) are presented. The period taken into account includes equipment manufactured for the projects Olympus, Meteosat, Italsat, TSS, Hipparcos, and ERS-1. A data base is presented, which includes the information for each component submitted to a failure investigation. Some statistics from the data base are highlighted. Component types or families in which nonconformity most frequently occurs are identified. Failure modes due to electrical, mechanical, and thermal stress are identified. Various examples of failure modes are reported. They can be grouped according to different cases on the basis of the results obtained upon completion of failure investigation. Possible corrective actions are described. An overview of critical aspects for each component family is reported.

ESA

Component Reliability; Data Bases; Failure Analysis; Failure Modes; Spacecraft Electronic Equipment; Stress Analysis

19910046411

Reliability prediction model for gyroscopes

Dumai, Aric; Winkler, Avi, Rafael Armament Development Authority, Israel; Jan 1, 1990; 5p; In English; See also A91-31032; Copyright; Avail: Issuing Activity

An example is presented of reliability-prediction analysis of displacement gyros and rate gyros based on a detailed failure-mode analysis. Performance reliability and technical reliability are dealt with using different models for each to determine the reliability of the entire instrument. Miner's rule and reduced energy and statistical safety-factor methods are used. A Bayesian approach is used for the reliability demonstration.

AIAA

Bayes Theorem; Component Reliability; Failure Analysis; Failure Modes; Gyroscopes; Prediction Analysis Techniques

19910046441 NASA Lewis Research Center, Cleveland, OH, USA

Model-OA wind turbine generator - Failure modes and effects analysis

Klein, William E., NASA Lewis Research Center, USA; Lali, Vincent R., NASA Lewis Research Center, USA; Jan 1, 1990; 4p; In English; See also A91-31032

Contract(s)/Grant(s): DE-AB29-79ET-20370; Avail: Issuing Activity

The results failure modes and effects analysis (FMEA) conducted for wind-turbine generators are presented. The FMEA was performed for the functional modes of each system, subsystem, or component. The single-point failures were eliminated for most of the systems. The blade system was the only exception. The qualitative probability of a blade separating was estimated at level D-remote. Many changes were made to the hardware as a result of this analysis. The most significant change was the addition of the safety system. Operational experience and need to improve machine availability have resulted in subsequent changes to the various systems, which are also reflected in this FMEA.

AIAA

Failure Analysis; Failure Modes; Turbine Blades; Wind Turbines

19910046456

Shortcomings in MIL-STD-1629A guidelines for criticality analysis

Agarwala, Ajay S., Boeing Helicopters, USA; Jan 1, 1990; 3p; In English; See also A91-31032; Copyright; Avail: Issuing Activity

Some shortcomings in the industry guidelines MIL-STD-1629A in performing failure mode, effects, and criticality analyses are highlighted. It is shown that, if the MIL-STD-1629A guidelines are followed, then the contribution of several terms to the item-criticality numbers (the final step in completing a criticality analysis) is erroneously omitted. As a result, the item-criticality

numbers for the lower severities of the item are incorrect. As a separate issue, a broader definition of beta is recommended to properly treat failures in redundant systems.

AIAA

Failure Analysis; Failure Modes; Reliability Analysis

19920003070 National Research Council of Canada, Structures and Materials Lab., Ottawa Ontario, Canada

General introduction to engineering failure analysis

Wallace, W., National Research Council of Canada, Canada; Jun 19, 1990; 36p; In English; Short Course on Failure Analysis, Oct. 1990, Doha, Qatar

Contract(s)/Grant(s): NAE PROJ. 07344

Report No.(s): NRC-LTR-ST-1773; Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

This report describes the importance of failure analysis as a discrete branch of engineering science as a basis for the retroactive design of engineering components. The general approach to failure analysis is described in terms of the collection and use of all available design data, as well as information on the operating environment. The principal diagnostic tools used in failure analysis are described, including the use of visual inspection, stress analysis, optical and electron microscopy, fractography, x-ray diffraction and radiography, other nondestructive inspection techniques and mechanical testing. Examples are provided of the failure analysis of engineering components, including: (1) overload followed by plastic deformation, (2) overload followed by brittle fracture, (3) overload and brittle fracture due to quenching induced stresses, (4) fatigue failure of an aircraft propeller blade due to residual tensile stresses, and (5) brittle fracture of a developmental powder fabricated turbine disc due to inadequate control of the manufacturing process. Development of a thorough understanding of the materials employed and the way they respond to manufacturing processes and service operating conditions are extremely important. Apparently minor changes in operating conditions can result in dramatic changes in the way materials respond and may completely invalidate the original design assumptions.

CASI

Design Analysis; Failure Analysis; Failure Modes

19920007123 Allied-Signal Aerospace Co., Kansas City, MO, USA

Analysis of electronic component failures using high-density radiography

Tuohig, W. D., Allied-Signal Aerospace Co., USA; Potter, T. J., Allied-Signal Aerospace Co., USA; Nov 1, 1991; 7p; In English; 17th; International Symposium for Testing and Failure Analysis, 11-15 Nov. 1991, Los Angeles, CA, USA

Contract(s)/Grant(s): DE-AC04-76DP-00613

Report No.(s): DE92-002457; KCP-613-4586; CONF-911115-3; Avail: CASI; A02, Hardcopy; A01, Microfiche

The exceptional resolution and nondestructive nature of microfocus radiography has proven to be extremely useful in the diagnosis of electronic component failures, particularly when the components are contained in sealed or encapsulated assemblies. An epoxy-encapsulated NTC thermistor and an epitaxial silicon P-N junction photodetector are examples of discrete devices in which the cause of failure was correctly hypothesized directly from a radiographic image. Subsequent destructive physical examinations confirmed the initial hypothesis and established the underlying cause in each case. The problem in a vacuum switch tube which failed to function was apparent in the radiographic image, but the underlying cause was not clear. However, radiography also showed that the position of a flat cable in the assembly could contribute to failure, an observation which resulted in a change in manufacturing procedure. In each of these instances, microradiography played a key role in decisions concerning the root cause of failure, product viability, and corrective action.

DOE

Electronic Equipment; Failure Analysis; Failure Modes; Gamma Rays; Radiography

19920050197

Failure modes and AE characteristics of carbon fabric composites

Sun, Feng; Kimpara, Isao; Kageyama, Kazuro; Suzuki, Toshio; Ohsawa, Isamu, Tokyo, University, Japan; Jan 1, 1991; 10p; In English; 8th; International Conference on Composite Materials (ICCM/8), July 15-19, 1991, Honolulu, HI, USA; Sponsored by SAMPE; See also A92-32535; Avail: Issuing Activity

Static tensile failure behaviors and AE (acoustic emission) characteristics of non-notched and hole-notched carbon fabric composites was discussed in the present paper. Failure patterns of these composites were observed and then related to the AE parameters. The experimental results show that the arrangements and locations of failures were dependent on weave structures.

It was concluded that the initiation and propagation of different failure modes could be evaluated by AE parameters and the behaviors of micro-failure modes of notched specimens were affected by stress concentration and hole size.

AIAA

Acoustic Emission; Carbon Fiber Reinforced Plastics; Fabrics; Failure Analysis; Failure Modes; Fracture Mechanics

19920059442

An alternative method for preparing FMECA's

Sexton, Ronald D., British Aerospace /Dynamics/, Ltd., UK; Jan 1, 1991; 4p; In English; Annual Reliability and Maintainability Symposium, Jan. 29-31, 1991, Orlando, FL, USA; See also A92-42051; Copyright; Avail: Issuing Activity

After evaluating the practical difficulties associated with the application of MIL-STD-1629-based failure-modes-and-effects analyses, a cost-saving alternative methodology is proposed which, in addition to being rapid, allows reliability engineers to influence design decisions. This method follows the spirit rather than the letter of MIL-STD-1629, and has been found to surmount the inherent problem of the standard that is associated with a single failure's ability to effectively disrupt only one system function.

AIAA

Design Analysis; Failure Analysis; Failure Modes; Reliability Engineering

19920059444

FMECA - An integrated approach

Luthra, Puran, Electronics and Space Corp., USA; Jan 1, 1991; 7p; In English; Annual Reliability and Maintainability Symposium, Jan. 29-31, 1991, Orlando, FL, USA; See also A92-42051; Copyright; Avail: Issuing Activity

Failure modes/effects/criticality analyses (FMECA) are performed by reliability engineers to ascertain the effects of probable component and assembly failure modes. In addition to improving the FMECA analysis and format, an effort is made to develop software capable of transferring data for various reports in order to eliminate duplications. The results of these FMECA improvements allows its results to serve as automated inputs to such other analyses as those of logistics support, fault trees, and test requirement documents, in the interest of meeting TQM objectives.

AIAA

Failure Analysis; Failure Modes; Reliability Engineering; Systems Analysis

19920059446

FMECA, the right way

McKinney, Barry T., USAF, Rome Air Development Center, USA; Jan 1, 1991; 7p; In English; Annual Reliability and Maintainability Symposium, Jan. 29-31, 1991, Orlando, FL, USA; See also A92-42051; Avail: Issuing Activity

The failure modes, effects, and criticality analysis (FMECA) makes its primary contribution to the early identification of catastrophic, critical, and safety-related failure possibilities, with a view to their preclusion or minimization through design changes. The present evaluation of an advanced approach-radar system by means of FMECA has identified a total of seven major deficiencies, five of which are commonly encountered in FMECA activities; they include a lack of defined causes of failure, unsuitable severity classifications, a lack of sources for data, obliviousness to analogous failure modes in similar previous designs, and a poverty of recommendations on the operation and support of the system in question. Corrections for these deficiencies are presented.

AIAA

Design Analysis; Failure Analysis; Failure Modes; Reliability Engineering

19920073592

Role of failure-mechanism identification in accelerated testing

Hu, Jun Ming; Barker, Donald B.; Dasgupta, Abhijit; Arora, Ajay K., Maryland, University, USA; Jan 1, 1992; 8p; In English; Annual Reliability and Maintainability Symposium, Jan. 21-23, 1992, Las Vegas, NV, USA; Sponsored by IEEE; See also A92-56201; Copyright; Avail: Issuing Activity

The authors summarize common failure mechanisms in electronic devices and packages and investigate possible failure mechanism shifting during accelerated testing. It is noted that in accelerated tests the stress applied can produce failure mechanisms that are different from those observed during actual service conditions. Therefore, failure mechanism identification and the setting up of stress limits for all types of accelerated life tests in order to prevent shifting of the original dominant failure mechanism is necessary. Research on failure mechanism detection needs to be conducted to provide better approaches for failure

mechanism identification. If failure mechanism shifting occurs in an accelerated life test, the test data will be unrepresentative for the reliability under actual operating conditions.

AIAA

Accelerated Life Tests; Electronic Equipment; Failure Analysis; Failure Modes

19920073615

Using causal reasoning for automated failure modes and effects analysis (FMEA)

Bell, Daniel; Cox, Lisa; Jackson, Steve; Schaefer, Phil, Martin Marietta Astronautics Group, USA; Jan 1, 1992; 11p; In English; Annual Reliability and Maintainability Symposium, Jan. 21-23, 1992, Las Vegas, NV, USA; Sponsored by IEEE; See also A92-56201; Copyright; Avail: Issuing Activity

The authors have developed a tool that automates the reasoning portion of a failure modes and effects analysis (FMEA). It is built around a flexible causal reasoning module that has been adapted to the FMEA procedure. The approach and software architecture have been proven. A prototype tool has been created and successfully passed a test and evaluation program. The authors are expanding the operational capability and adapting the tool to various CAD/CAE (computer-aided design and engineering) platforms.

AIAA

Causes; Computer Aided Design; Failure Analysis; Failure Modes; Reliability Engineering

19920073619

The Shuttle processing contractors (SPC) reliability program at the Kennedy Space Center - The real world

McCrea, Terry, Lockheed Space Operations Co., USA; Jan 1, 1992; 3p; In English; Annual Reliability and Maintainability Symposium, Jan. 21-23, 1992, Las Vegas, NV, USA; Sponsored by IEEE; See also A92-56201; Copyright; Avail: Issuing Activity

The Shuttle Processing Contract (SPC) workforce consists of Lockheed Space Operations Co. as prime contractor, with Grumman, Thiokol Corporation, and Johnson Controls World Services as subcontractors. During the design phase, reliability engineering is instrumental in influencing the development of systems that meet the Shuttle fail-safe program requirements. Reliability engineers accomplish this objective by performing FMEA (failure modes and effects analysis) to identify potential single failure points. When technology, time, or resources do not permit a redesign to eliminate a single failure point, the single failure point information is formatted into a change request and presented to senior management of SPC and NASA for risk acceptance. In parallel with the FMEA, safety engineering conducts a hazard analysis to assure that potential hazards to personnel are assessed. The combined effort (FMEA and hazard analysis) is published as a system assurance analysis. Special ground rules and techniques are developed to perform and present the analysis. The reliability program at KSC is vigorously pursued, and has been extremely successful. The ground support equipment and facilities used to launch and land the Space Shuttle maintain an excellent reliability record.

AIAA

Ground Support Systems; Reliability Analysis; Space Transportation System; Spacecraft Reliability

19920073632

A blackboard model of an expert system for failure mode and effects analysis

Russomanno, David J., Intergraph Corp., USA; Bonnell, Ronald D.; Bowles, John B., South Carolina University, USA; Jan 1, 1992; 8p; In English; Annual Reliability and Maintainability Symposium, Jan. 21-23, 1992, Las Vegas, NV, USA; Sponsored by IEEE; See also A92-56201; Copyright; Avail: Issuing Activity

The design of an expert system to assist in performing a failure mode and effects analysis (FMEA) is approached from a knowledge-use-level perspective to provide a thorough understanding of the problem and insight into the knowledge and expertise needed to automate the FMEA process. A blackboard model is a conceptual model that provides the organizational principles required for the design of an expert system without actually specifying its realization. In the blackboard model of an intelligent FMEA, the system is functionally decomposed into a set of knowledge sources, each containing the knowledge associated with a subfunction of the FMEA process. The conceptual model derived can be used to evaluate attempts to automate the FMEA process, and it can serve as the foundation for further research into automating the FMEA process. An example is presented illustrating the interaction among the knowledge sources in the blackboard model to construct a FMEA for a domestic hot water heater.

AIAA

Expert Systems; Failure Analysis; Failure Modes; Reliability Engineering

19930035273

A method for the evaluation of failure probability in redundant structures

An, Weiguang; Cai, Yinlin, Harbin Shipbuilding Engineering Inst., China; Acta Armamentarii; May 1992; ISSN 1000-1093, 1992, pp. 92-96.; In Chinese; Avail: Issuing Activity

A simple method is proposed to evaluate the failure probability in structures. Based on the bounding criterion and the formulation of the maximum contribution of the excluded failure modes to the structure failure probability, the lower and the upper bounds of failure probability are estimated by branching and bounding operations selecting only the dominant failure modes to complete the calculation of failure probability in a structure. A numerical example is provided to demonstrate the validity of the proposed method.

AIAA

Dynamic Structural Analysis; Failure Analysis; Failure Modes

19930043788

Reliability growth through application of accelerated reliability techniques and continual improvement processes

Schinner, Charles E., Hewlett-Packard Co., USA; In: Institute of Environmental Sciences, Annual Technical Meeting, 37th, San Diego, CA, May 6-10, 1991, Proceedings (A93-27778 09-38); 1991, pp. 347-354.; In English; See also A93-27778; Copyright; Avail: Issuing Activity

Accelerated reliability techniques, the test-analyze-correct-verify process, and the broad spectrum stress portfolio are discussed. It is concluded that using these parallel strategies enables a comprehensive evaluation of the power supply in an abbreviated evaluation time period. This evaluation uncovers design, component, and manufacturing deficiencies in the product that would have taken months of field warranty data to observe. This process makes it possible to considerably improve the reliability of the product and satisfy customers without affecting the product schedule.

AIAA

Failure Analysis; Failure Modes; Reliability Analysis; Stress Distribution

19940007091 Aeronautical Radio, Inc., Advanced Research and Development Group., Annapolis, MD, USA

Design for testability and diagnosis at the system-level

Simpson, William R., Aeronautical Radio, Inc., USA; Sheppard, John W., Aeronautical Radio, Inc., USA; NASA. Johnson Space Center, Sixth Annual Workshop on Space Operations Applications and Research (SOAR 1992), Volume 2; Feb 1, 1993, pp. p 627-632; In English; Avail: CASI; A02, Hardcopy; A03, Microfiche

The growing complexity of full-scale systems has surpassed the capabilities of most simulation software to provide detailed models or gate-level failure analyses. The process of system-level diagnosis approaches the fault-isolation problem in a manner that differs significantly from the traditional and exhaustive failure mode search. System-level diagnosis is based on a functional representation of the system. For example, one can exercise one portion of a radar algorithm (the Fast Fourier Transform (FFT) function) by injecting several standard input patterns and comparing the results to standardized output results. An anomalous output would point to one of several items (including the FFT circuit) without specifying the gate or failure mode. For system-level repair, identifying an anomalous chip is sufficient. We describe here an information theoretic and dependency modeling approach that discards much of the detailed physical knowledge about the system and analyzes its information flow and functional interrelationships. The approach relies on group and flow associations and, as such, is hierarchical. Its hierarchical nature allows the approach to be applicable to any level of complexity and to any repair level. This approach has been incorporated in a product called STAMP (System Testability and Maintenance Program) which was developed and refined through more than 10 years of field-level applications to complex system diagnosis. The results have been outstanding, even spectacular in some cases. In this paper we describe system-level testability, system-level diagnoses, and the STAMP analysis approach, as well as a few STAMP applications.

Author (revised)

Complex Systems; Failure Analysis; Failure Modes; Fast Fourier Transformations; Information Flow; Information Theory; Systems Analysis

19940022539 Swedish Inst. for Materials Testing, Boras, Sweden

Baseline for a Nordtest method. Reliability stress screening of components. A guide for component users

Boerjesson, Arne, Swedish Inst. for Materials Testing, Sweden; Loll, Valter, Swedish Inst. for Materials Testing, Sweden; Kristensen, Allan Moller, Swedish Inst. for Materials Testing, Sweden; Jan 1, 1993; 119p; In English

Contract(s)/Grant(s): NORDTEST PROJ. 1034-92

Report No.(s): PB94-123775; SP-RAPP-1993:48; Avail: CASI; A06, Hardcopy; A02, Microfiche

A method for reliability stress screening (RSS) of components has been developed and is proposed to form a baseline for a Nordtest-method. Before issuance as a Nordtest-method, it is proposed to supplement this report regarding possible failure modes and to make some editorial changes. The development work has been done in cooperation between the Swedish National Testing and Research Institute (SP) and Elektronikcentralen (EC) and was financed by Nordtest. The method makes use of methods described in IEC standard 1163. It is complementary to Nordtest-method NT ELEC 018 which defines a method for RSS of printed wiring assemblies. The purpose of the method is to give guidance to the component user and equipment manufacturer for the specification and the performance of screening for different cases. Five cases based on the users' different aims for the screening are defined in the method. Examples of the design of a screening program are given for 4 different component generic families. These are chosen as being the component families with the highest rate of early failures as defined by a questionnaire performed during the work with the Nordtest-method NT ELEC 018.

NTIS

Equipment Specifications; Failure Analysis; Failure Modes; Printed Circuits; Reliability Analysis; Stress Analysis; Thermal Stresses; Vibration Tests

19940033450

The integrating with FMECA reliability prediction method

Jin, Xingming, 615 Research Inst. of Aero-Space Industry, China; Tu, Qingci; Lu, Tingxiao, Beijing Univ., China; Beijing University of Aeronautics and Astronautics, Journal; Jan. 1992; ISSN 1001-5965, 1199, pp. 32-37.; In Chinese; Avail: Issuing Activity

The failure of any part always displays a certain failure mode. When a part fails with different failure modes, the effects of these failure modes on the product are also different. In order to improve the accuracy of reliability prediction integrating with FMECA, this paper analyzes the effect of the failure mode and its criticality thoroughly. The reliability prediction model integrated with FMECA is established. It can predict products mission reliability and mission time between criticality failures. In order to facilitate popularization, the author developed a related software package and ran some practical cases. Finally, integration with the FMECA reliability prediction method is compared with the conventional one.

AIAA

Failure Analysis; Failure Modes; Predictions; Reliability

19950016882 Thomas Nelson Community Coll., Dept. of Engineering and Technology., Hampton, VA, USA

Reliability analysis in the Office of Safety, Environmental, and Mission Assurance (OSEMA) *Abstract Only*

Kauffmann, Paul J., Thomas Nelson Community Coll., USA; Hampton Univ., 1994 NASA-HU American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program; Dec 1, 1994, pp. p 84; In English; Avail: Issuing Activity

The technical personnel in the SEMA office are working to provide the highest degree of value-added activities to their support of the NASA Langley Research Center mission. Management perceives that reliability analysis tools and an understanding of a comprehensive systems approach to reliability will be a foundation of this change process. Since the office is involved in a broad range of activities supporting space mission projects and operating activities (such as wind tunnels and facilities), it was not clear what reliability tools the office should be familiar with and how these tools could serve as a flexible knowledge base for organizational growth. Interviews and discussions with the office personnel (both technicians and engineers) revealed that job responsibilities ranged from incoming inspection to component or system analysis to safety and risk. It was apparent that a broad base in applied probability and reliability along with tools for practical application was required by the office. A series of ten class sessions with a duration of two hours each was organized and scheduled. Hand-out materials were developed and practical examples based on the type of work performed by the office personnel were included. Topics covered were: Reliability Systems - a broad system oriented approach to reliability; Probability Distributions - discrete and continuous distributions; Sampling and Confidence Intervals - random sampling and sampling plans; Data Analysis and Estimation - Model selection and parameter estimates; and Reliability Tools - block diagrams, fault trees, event trees, FMEA. In the future, this information will be used to review and assess existing equipment and processes from a reliability system perspective. An analysis of incoming materials sampling plans was also completed. This study looked at the issues associated with Mil Std 105 and changes for a zero defect acceptance sampling plan.

Author

Engineering Management; Reliability Analysis; Reliability Engineering; Space Missions

19960044575 Wuppertal Univ., Germany

Safety and reliability analysis of a technical system applying the multistate coherent system analysis for evaluating a finite number of normal operating modes and failure modes *Final Report Sicherheits- und Zuverlaessigkeitsanalyse bei endlich vielen Betriebs-/ Ausfallarten eines technischen Systems unter Zugrundelegung mehrwertiger Modelle -- Abschlussbericht* Rakowsky, U., Wuppertal Univ., Germany; Meyna, A., Wuppertal Univ., Germany; Peters, O. H., Wuppertal Univ., Germany; 1992; 387p; In German; Report and separate annex

Contract(s)/Grant(s): DFG-Pe-179/7-1/2

Report No.(s): INIS-mf-15092; No Copyright; Avail: Issuing Activity (Fachinformationszentrum (FIZ), Karlsruhe, Germany)

The further development of multistate coherent systems analysis is explained which is based on monotone multistate component analysis in contrast to the discrete state component analysis. The method applied allows to one derive, from the data giving the failure and the lifetime probabilities of a component, the multi-valued probabilities as a function of time. The method is particularly suitable for evaluating the reliability of components subject to aging processes which are not quantitatively measurable. Main applications are in nuclear engineering and in aircraft and spacecraft engineering.

FIZ

Failure Analysis; Reliability Analysis; Component Reliability; Failure Modes; Safety Management

19970016788 California Univ., Engineering Systems Research Center, Berkeley, CA USA

Failure Models Derived Through the Indifference Principle (UCB-ENG-8293) *Final Report, 1 Oct. 1992 - 31 Mar. 1996*

Barlow, Richard E., California Univ., USA; Mar. 1996; 7p; In English

Contract(s)/Grant(s): F49620-93-1-0011; AF Proj. 2304

Report No.(s): AD-A315265; AFOSR-TR-96-0489; No Copyright; Avail: CASI; A02, Hardcopy; A01, Microfiche

This draft of a new book entitled ENGINEERING RELIABILITY concerns failure data analysis, the economics of maintenance policies and system reliability. The purpose of this book is to develop the use of probability in engineering reliability and maintenance problems. We use probability models in the (1) analysis of failure data; (2) decision relative to planned maintenance; and (3) prediction relative to preliminary design. Engineering applications are emphasized and are used to motivate the methodology presented. Part 1 is devoted to the analysis of failure data, particularly lifetime data and failure counts. We begin by using a new approach to probability applications. The approach starts with finite populations and derives conditional probability models based on engineering and economic considerations. Infinite population conditional probability models most often used are approximations to these finite population models. The derived conditional probability models are then the basis for likelihood functions useful for the analysis of failure data. Part 2 is devoted to the economics of maintenance decisions. We begin with the economics of replacement decisions. Emphasis is on the time value of money and discounting. Then we consider inspection policies relative to operating systems and production sampling. Part 3 is devoted to system reliability. We begin with efficient algorithms for computing network reliability. Networks or block diagrams are abstract system representations useful for both reliability prediction and maintenance considerations. Availability and maintainability formulas are derived and used in applications. Fault tree analysis as presented is one of the most useful tools in identifying system failure modes and effects.

DTIC

Failure Analysis; Failure Modes; Performance Prediction; Probability Theory; Reliability Engineering; System Failures

1998000930 Technische Univ., Delft, Netherlands

Methods for Assessing the Failure Frequency of Underground Gas Pipelines with Historical Data and Structured Expert Judgment

Cooke, Roger, Technische Univ., Netherlands; 1996; ISSN 0922-5641; 68p; In English

Report No.(s): PB97-192678; REPT-96-75; Copyright Waived; Avail: CASI; A04, Hardcopy; A01, Microfiche

This report describes a ranking tool developed at Gasunie in cooperation with the Delft University of Technology. The ranking tool is based on a model for the frequency of failure per kilometer year of a gas pipeline. The model is quantified using data from Gasunie and using structured expert judgment from an international panel of experts. The quantification explicitly accounts for uncertainty in the assessment of failure frequencies. Calibration data is used to validate the statistical accuracy and informativeness of the combined expert judgements.

NTIS

Underground Structures; Failure Analysis; Failure Modes; Gas Pipes; Pipelines

19980006554 Vanderbilt Univ., Civil and Environmental Engineering, Nashville, TN USA

Multi-Disciplinary System Reliability Analysis *Final Report*

Mahadevan, Sankaran, Vanderbilt Univ., USA; Han, Song, Vanderbilt Univ., USA; Dec. 1997; 99p; In English
Contract(s)/Grant(s): NAG3-1372

Report No.(s): NASA/CR-97-206652; NAS 1.26:206652; No Copyright; Avail: CASI; A05, Hardcopy; A02, Microfiche

The objective of this study is to develop a new methodology for estimating the reliability of engineering systems that encompass multiple disciplines. The methodology is formulated in the context of the NESSUS probabilistic structural analysis code developed under the leadership of NASA Lewis Research Center. The NESSUS code has been successfully applied to the reliability estimation of a variety of structural engineering systems. This study examines whether the features of NESSUS could be used to investigate the reliability of systems in other disciplines such as heat transfer, fluid mechanics, electrical circuits etc., without considerable programming effort specific to each discipline. In this study, the mechanical equivalence between system behavior models in different disciplines are investigated to achieve this objective. A new methodology is presented for the analysis of heat transfer, fluid flow, and electrical circuit problems using the structural analysis routines within NESSUS, by utilizing the equivalence between the computational quantities in different disciplines. This technique is integrated with the fast probability integration and system reliability techniques within the NESSUS code, to successfully compute the system reliability of multi-disciplinary systems. Traditional as well as progressive failure analysis methods for system reliability estimation are demonstrated, through a numerical example of a heat exchanger system involving failure modes in structural, heat transfer and fluid flow disciplines.

Author

Reliability Analysis; Failure Analysis; Reliability Engineering; Structural Engineering; Systems Analysis; Fluid Mechanics; Fluid Flow; Failure Modes; Mechanical Properties; Structural Analysis

19980008338 Mansour Engineering, Inc., Berkeley, CA USA

Assessment of Reliability of Ship Structures. Appendices *Final Report*

Mansour, A., Mansour Engineering, Inc., USA; Wirsching, P., Mansour Engineering, Inc., USA; Luckett, M., Mansour Engineering, Inc., USA; Plumpton, A., Mansour Engineering, Inc., USA; 1997; 165p; In English; See also PB97-141584.

Report No.(s): PB97-141592; SSC-398A; No Copyright; Avail: CASI; A08, Hardcopy; A02, Microfiche

A detailed approach has been developed for assessing structural safety and reliability of ships. The methodology provides a means for determining reliability levels associated with a hull girder, stiffened panel and unstiffened plate modes of failure. Procedures for estimating the non-linear extreme sea loads and structural strength which are required for the reliability analysis have been developed. Fatigue reliability of ship structural details was also addressed and further developed. The methodology was demonstrated on four ships; two cruisers, a double hull tanker and an SL-7 containership. Reliability levels associated with each mode of failure of these ships were determined and compared. Sensitivity analysis has been conducted which provides sensitivity of a safety index to variations in design variables associated with extreme loading conditions as with fatigue loads. Recommendations are made of target reliability levels for each ship type and failure mode. Design variables that have the highest impact on reliability have been identified and some guidelines are provided for improving design criteria.

NTIS

Structural Analysis; Hulls (Structures); Reliability Analysis; Failure Modes; Structural Design Criteria; Failure Analysis; Ships

19980060342

Redundancy verification analysis - An alternative to FMEA for low cost missions

Sincell, Jeffry, Worst Case Associates, Inc., USA; Perez, Reinaldo J., JPL, USA; Noone, Patrick, JPL, USA; Oberhettinger, David, Logicon Syscon, Inc., USA; 1998, pp. 54-60; In English; Copyright; Avail: Aeroplus Dispatch

Redundancy verification analysis (RVA) is a promising technique for verifying internal redundancy within electronic assemblies, as well as 'cross-strap' redundancy between them, in cost or schedule constrained spacecraft development projects. RVA tracks a signal from its source to the end of the signal path, through all the subsystems along the way, including software. When performed in conjunction with a worst case analysis, RVA may obviate the need for a system-level failure mode and effects analysis, providing a detailed examination of the actual workings of system hardware, software, and interfaces. Demonstrated by JPL on the Mars Global Surveyor project, use of RVA is consistent with NASA's emphasis on 'faster-better-cheaper' spacecraft design and development.

Author (AIAA)

Spacecraft Electronic Equipment; Redundancy; Failure Analysis; Failure Modes; Fault Tolerance; Spacecraft Reliability

19980060405

FMEA For multiple failures

Price, Christopher J., Univ. of Wales, UK; Taylor, Neil S., Univ. of Wales, UK; 1998, pp. 43-47; In English; Copyright; Avail: Aeroplus Dispatch

Failure mode and effects analysis (FMEA) usually only considers single failures in a system. This is because the consideration of all possible combinations of failures in a system is impractical for any but the very simplest example systems. Even if simulation is used to automate the work of producing an FMEA report, consideration of all possible combinations of failures is not possible, and even if it were possible, an engineer could not be expected to spend the time needed in order to read, understand, and act on all of the results. This paper shows how to use approximate failure rates for components to select the most likely combinations of failures for simulation, and how to prune the resulting report to such an extent that it is practical for an engineer to study and act on the results. The strategy outlined in the paper has been applied to a number of automotive electrical subsystems, and the results have confirmed that the strategy described here works well for realistically complex subsystems.

Author (AIAA)

System Failures; Failure Modes; Circuit Reliability; Failure Analysis

19980087674

Effective techniques of FMEA at each life-cycle stage

Onodera, Katsushige, Hitachi, Japan; 1997, pp. 50-56; In English; Copyright; Avail: AIAA Dispatch

The Failure Mode and Effects Analysis (FMEA) is a widely used analytical tool. It is especially useful in the conduct of reliability, maintainability, and safety analyses. Such analyses are commonly used to identify failures of significant consequence and those affecting system performance. An investigation of some 100 FMEA applications revealed that the FMEA technique is useful in virtually every stage of the modern industrial process. Although FMEAs were most frequently used in the initial design and development stages of a project, they were also of value in the manufacturing stage. In support of manufacturing, FMEAs contributed in deriving the optimum construction method and schedule. Even after construction of the plant, FMEAs were again found to add value in the analyses of day-to-day plant operations and maintenance activities, or the use stage. The continuous application of the FMEA process over the life-cycle of a project is ensured by the preparation of the individual FMEA worksheets for each stage. Examples of such worksheets are presented and discussed in this paper. FMEAs are evaluated by either of two methods: Criticality or Risk Priority Number (RPN). The elements which comprise the Criticality and RPN method are also presented in this paper.

Author (AIAA)

Failure Modes; Life Cycle Costs; Failure Analysis; Safety Factors

19980097486

Analysis approach to reliability improvement

Krasich, Milena, Lucent Technologies, USA; 1997, pp. 177-182; In English; Copyright; Avail: AIAA Dispatch

Evaluation of reliability growth testing of an already designed item used to be a basic traditional approach to reliability improvement. There are many reasons why testing may not be a desirable vehicle, such as cost, test length for high reliability, tight delivery schedules, small sample sizes for desired confidence, costly design changes, and the like. Analysis approach evolves from the standard reliability tasks that are normally done on a project such as FMECA or FMEA and Worst Case Analysis. Stress/strength analysis performed for each identified failure mode provides information on their likelihood and determines the need for their mitigation through design changes. In that manner, likely failures are mitigated before completion of the design, and the initial product mean time to failure is increased. If and when the same system is later subjected to a reliability growth program, the growth rate does not have to be aggressively high, or the test duration does not have to be extensive. The analysis method thus provides a faster and cheaper way to achieve reliability improvement.

Author (AIAA)

Reliability Analysis; Design to Cost; Stress Analysis; Failure Modes; Q Factors

19980120567

Annual Reliability and Maintainability Symposium, Las Vegas, NV, Jan. 22-25, 1996, Proceedings
1996; In English

Report No.(s): ISBN 0-7803-3112-5; ISBN 0-7803-3112-5@ISSN 0149-1; Copyright; Avail: Aeroplus Dispatch

The papers presented in this volume focus on various aspects of reliability and maintainability, including standards and specifications; failure mode, effects, and criticality analysis; simulation; system assurance; system safety and risk assessment; software design; accelerated testing; fault trees; design for reliability; and reliability prediction. Specific topics discussed include

FMEA/CIL implementation for the Space Shuttle new turbopumps; modeling and simulation of a satellite constellation based on Petri nets; an overview of environmental reliability testing; Space Shuttle program risk management; and an analytic approach for evaluating failure-probability in complex aerospace systems.

AIAA

Conferences; Reliability; Maintainability

19980120570

Commercial off-the-shelf (COTS) - A challenge to military equipment reliability

Demko, Edward, Northrop Grumman Corp., USA; 1996, pp. 7-12; In English; Copyright; Avail: Aeroplus Dispatch

COTS offers the promise of technology advancement, low cost, and reduced acquisition time. Unfortunately, it also offers the opportunity for a reliability and logistics disaster because commercial parts, standards, and practices may not meet military requirements. COTS hardware is expected to have the following characteristics: low cost, currently available from multiple suppliers, built to documented standards in high volume production with a mature design. The reliability challenge in the next decade will be to manage COTS to take advantage of the promise and avoid the disaster. This can be done by carefully selecting the COTS vendors, thoroughly testing the hardware/software, and applying only those analyses and data requirements (ESS, EQT, verification testing, prediction, FMEA, derating, parts control, and FRACAS/FRB) to ensure reliability performance and logistics support. This paper offers some guidance in managing COTS program elements and provides insight into their impact on reliability.

Author (AIAA)

Military Technology; Reliability; Cost Analysis

19980120575

FMEA automation for the complete design process

Montgomery, Thomas A., Ford Motor Co., USA; Pugh, David R., Univ. of Wales, UK; Leedham, Steve T., Ford Motor Co., UK; Twitchett, Steve R., Jaguar Cars, Ltd., UK; 1996, pp. 30-36; In English

Contract(s)/Grant(s): SERC-GR/H96973; Copyright; Avail: Aeroplus Dispatch

Performing an FMEA during the design stage is a valuable technique for improving the reliability of a product. Unfortunately, the traditional brainstorming approach is also very tedious, time consuming, and error prone. Automating the process promises the generation of a more complete, consistent FMEA worksheet in a fraction of the time currently required. However, to be truly valuable, this automation must follow the product through the entire design cycle at each level of design: architecture, subsystem, and component. This paper presents an FMEA automation approach that spans the entire design cycle for electrical/electronic circuits. Brainstorming is replaced by computer simulation of failure modes and their effects. Qualitative simulation is used in the early (architectural) stages when design detail is not available. As the design progresses, the qualitative simulation gives way to quantitative simulation. Throughout, the information required to perform the FMEA is gleaned from that used to understand the nominal behavior of the circuit; thus the relief from brainstorming is not offset by a new modeling burden. Sample results from software supporting this approach are presented.

Author (AIAA)

Automation; Failure Modes; Failure Analysis; Computerized Simulation; Circuits; Electronic Equipment

19980120589

A combined analysis approach to assessing requirements for safety critical real-time control systems

Goddard, Peter L., Hughes Aircraft Co., USA; 1996, pp. 110-115; In English; Copyright; Avail: Aeroplus Dispatch

The combined Petri net and FMEA based approach to requirements analysis of safety critical embedded real time control systems developed by Hughes has been proven to provide a method of identifying incomplete, inconsistent, and incorrect requirements which may impact safety. This analysis method is applicable early in the design process, allowing requirement changes to be identified and implemented with minimal cost and schedule impact. It has been applied to several real world systems with positive results; missing, inconsistent, and incorrect requirements were identified in all cases. The approach is expected to be able to be implemented with minimal training of existing analysis personnel. Some training in Petri nets may be needed.

Author (AIAA)

Real Time Operation; Safety; Failure Modes; Failure Analysis; Control Systems Design; Petri Nets

19980121016

Ensuring quality

Wendt, Robert G., Martin Marietta Astronautics, USA; Berger, Kevin R., Martin Marietta Astronautics, USA; Palmer, Donald L., Martin Marietta Astronautics, USA; Sarafin, Thomas P., Instar Engineering and Consulting, Inc., USA; Spacecraft structures and mechanisms - From concept to launch; 1995, pp. 417-448; In English; Copyright; Avail: Aeroplus Dispatch

Some aspects of effective product quality assurance are addressed. The topics discussed are: development of manufacturing processes; control of parts, materials, and processes; response to discrepancies and damage; configuration management and control; and failure analysis.

AIAA

Quality Control; Manufacturing; Failure Modes; Failure Analysis

19980121917

Combining the Sneak Circuit Analysis with Failure Modes and Effects Analysis

Shen, Chengyu, Beijing Univ. of Aeronautics and Astronautics, China; Beijing University of Aeronautics and Astronautics, Journal; Oct. 1995; ISSN 1001-5965; Volume 21, no. 4, pp. 35-40; In Chinese; Copyright; Avail: AIAA Dispatch

The feasibility of integrating Failure Modes and Effects Analysis (FMEA) and Sneak Circuit Analysis (SCA) into comprehensive reliability analysis techniques is illustrated. The integrated approach will be able to examine a system more thoroughly than either SCA or FMEA alone do.

Author (AIAA)

System Failures; Sneak Circuit Analysis; Failure Modes; Reliability Analysis

19980175127

Rationalizing scheduled-maintenance requirements using reliability centered maintenance - A Canadian Air Force perspective

Hollick, Ludwig J., Aerospace Maintenance Development Unit, Canada; Nelson, Greg N., Aerospace Maintenance Development Unit, Canada; 1995, pp. 11-17; In English; Copyright; Avail: Aeroplus Dispatch

Failure Modes and Effects Analysis (FMEA) and Reliability Centered Maintenance (RCM)/Maintenance Steering Group (MSG) decision logic have been successfully used by military and commercial aviation manufacturers for over three decades to develop preventive maintenance programs for new aircraft fleets. However, once a fleet is in place, there is a requirement to periodically validate or rationalize the applicability and effectiveness of individual tasks in the program, and to adjust task frequencies. Experience has shown that it is inefficient to re-apply FMEA/RCM decision logic to every aircraft item on a fixed frequency basis. This paper identifies how the Canadian Air Force proposes to make more efficient and effective use of the in-service data it collects to identify those items for which the preventive maintenance requirement is ineffective or non-applicable. Moreover, it discusses how the same data source can be used in follow-up investigations to determine the actual failure mode history of an item as a basis for comparison with the FMEA, the basis upon which the requirement for the existing tasks is developed.

Author (AIAA)

Scheduling; Failure Modes; Aircraft Reliability; Spacecraft Reliability; Aircraft Maintenance; Spacecraft Maintenance

19980183209

Computational structural reliability analysis of a turbine blade

Millwater, H. R., Southwest Research Inst., USA; Wu, Y.-T., Southwest Research Inst., USA; May 1993; In English
Contract(s)/Grant(s): NAS3-24389

Report No.(s): ASME Paper 93-GT-237; Copyright; Avail: Aeroplus Dispatch

A system reliability methodology has recently been developed to determine accurately and efficiently the reliability of structures with multiple failure modes. This paper explores the computational implementation and application of the methodology through the structural system reliability calculation of a turbine blade subject to randomness in material properties. Failure due to creep, stress overload, and vibration is considered. The methodology consists of a probabilistic system reliability analysis methodology integrated with FEMs. The failure paths and failure modes are organized using a fault tree. An efficient method for assessing the reliability of a single failure mode, i.e., component reliability, is implemented as well as an efficient adaptive importance sampling method to assess the system reliability. A probabilistic structural analysis program, NESSUS, is used for the calculations.

Author (AIAA)

Turbine Blades; Failure Modes; Reliability Analysis; Structural Failure; Random Processes; Failure Analysis

19980206187 Alabama Univ., Industrial Engineering Dept., Tuscaloosa, AL USA

An Independent Evaluation of the FMEA/CIL Hazard Analysis Alternative Study

Ray, Paul S., Alabama Univ., USA; Oct. 1996; 8p; In English; See also 19980206153; No Copyright; Avail: CASI; A02, Hardcopy; A04, Microfiche

The present instruments of safety and reliability risk control for a majority of the National Aeronautics and Space Administration (NASA) programs/projects consist of Failure Mode and Effects Analysis (FMEA), Hazard Analysis (HA), Critical Items List (CIL), and Hazard Report (HR). This extensive analytical approach was introduced in the early 1970's and was implemented for the Space Shuttle Program by NHB 5300.4 (1D-2). Since the Challenger accident in 1986, the process has been expanded considerably and resulted in introduction of similar and/or duplicated activities in the safety/reliability risk analysis. A study initiated in 1995, to search for an alternative to the current FMEA/CIL Hazard Analysis methodology generated a proposed method on April 30, 1996. The objective of this Summer Faculty Study was to participate in and conduct an independent evaluation of the proposed alternative to simplify the present safety and reliability risk control procedure.

Author

Hazards; Risk; Safety; NASA Programs; Failure Analysis; Reliability Analysis; Failure Modes; Assessments

19980217761

Exploration methods in business process re-engineering

Rajala, Mikko, Corporate Technology, Finland; Savolainen, Tapani; Jagdev, Harinder; Computers in Industry; Sep, 1997; ISSN 0166-3615; Volume 33, no. 2-3, pp. 367-385; In English; Copyright; Avail: Issuing Activity

Understanding the reasons of process variation is recognized as a key to the successful management of business processes. Various exploration methods give the prospective users a chance to tackle such complex problems by means of computer. Two key methodologies within the domain of exploration methods is presented: simulation modeling and value analysis (VA).

EI

Failure Analysis; Failure Modes; Quality Control; Process Control (Industry); Value Engineering; Computerized Simulation

19980235210 Beijing Univ. of Aeronautics and Astronautics, Beijing, China

Study of FMEA Automation Technique for Airborne Power System

Songhua, Shen, Beijing Univ. of Aeronautics and Astronautics, China; Ying, Li, Beijing Univ. of Aeronautics and Astronautics, China; Rui, Kang, Beijing Univ. of Aeronautics and Astronautics, China; Journal of Beijing University of Aeronautics and Astronautics; Dec. 1997; ISSN 1001-5965; Volume 23, No. 6, pp. 805-809; In Chinese; No Copyright; Avail: Issuing Activity, Hardcopy, Microfiche

Advances in an automatic quantitative analysis method of failure modes and effects analysis with system transient simulation in the system design stage take a airborne power system as a case in point. by use of the method, every possible failure mode of elements and devices in the system is accounted to the system transient model and system is simulated. Then simulation results of the failure states, and the cruel level of every failure mode effect is determined in numerical quantities. Therefore, the automation of failure modes and effects analysis is realized.

Author

Failure Modes; Failure Analysis

19990012185

Integrative use of QFD and FMEA in planning process *Integrative Nutzung von QFD und FMEA bei Entwurfsprozessen*

Krusche, Thomas; Dilger, Elmar; Strasser, Michael; ZWF Zeitschrift fuer Wirtschaftlichen Fabrikbetrieb; Oct, 1997; ISSN 0947-0085; Volume 92, no. 10, pp. 507-510; In German; Copyright; Avail: Issuing Activity

An improvement in attention to quality aspects while a product is being created is achieved by providing an integration model comprising important parts of both preventive quality assurance methods QFD and FMEA. The model ensures methodical cohesion by rigorous parallel application of the functional and component aspect within the development process. It ensures that customer demands are met, that there is constant development documentation and that risk analysis is simplified.

Author (EI)

Failure Analysis; Failure Modes; Quality Control; Planning; Product Development; Models; Assessments; Risk

19990056047

The effect of failure-distribution specification-errors on maintenance costs

Maillart, Lisa M., Michigan, Univ., Ann Arbor, USA; Pollock, Stephen M., Michigan, Univ., Ann Arbor; 1999, pp. 69-77; In English; Copyright; Avail: AIAA Dispatch

This paper examines the problem of determining and evaluating optimal fixed-length inspection intervals for a single machine that operates continuously subject to nonobvious, random failures. Good-as-new repairs are performed when the machine is found to be failed. Both the fixed-interval inspection and replacement times are instantaneous. Two possible single parameter failure time distributions are used in this investigation: exponential and 2-Erlang. The focus of this paper, however, is on the consequences of mis-specifying the form of the failure distribution or the parameter value(s) of the failure distribution. Robustness analysis indicates that long-run expected cost per unit time is extremely robust to moderate errors in the specification of the expected time to failure (cost increases of less than 0.6 percent for +/- 20 percent error in expected failure time), when the form of the failure distribution is correct. Conversely, accurately specifying the mean time between failures, but incorrectly specifying the form of the failure distribution, results in significant increases in long run expected cost per unit time. Mistaking an exponential for a 2-Erlang, or vice versa, can result in cost increases of over 20 percent for reasonable values of cost parameters.

Author (AIAA)

Failure Analysis; Maintenance; Cost Estimates; Failure Modes; Machinery

19990056068

Equivalence relations within the failure mode and effects analysis

Spangler, C. S., Boeing Space & Communications Group, USA; 1999, pp. 352-357; In English; Copyright; Avail: AIAA Dispatch

The reliability and maintainability community has long sought ways to improve the value of the Failure Mode and Effects Analysis (FMEA) as a means to influence the final design during early development stages. In addition to eliminating unacceptable single-point failures, provisions for Fault Detection and Fault Isolation (FD/FI) provide the most significant areas where the design can be influenced by the FMEA. This paper examines the mathematical concept of equivalence relations and partitions within the FMEA to: influence the FD/FI design; enable the reuse of functional analysis in the subsequent interface and piece part analyses; and improve the quality and cost of the analysis. Set algebra is applied to partition all failure modes and their consequences into disjoint subsets known as fault equivalence classes. Equivalence classes are created as a method for managing all failure mode consequences. Assessing the significance of undetected failure modes and the associated ambiguity in locating the manifested system anomaly requires the analyst to first identify what equivalency exists. When this equivalency is known early in the design development stages of a program, compensating provisions can be designed in or adjusted to achieve high degrees of maintainability. Knowledge of equivalence classes provides insight into the mechanisms by which failure modes affect a system.

Author (AIAA)

Failure Modes; Reliability Analysis; Maintenance; Fault Detection; Equivalence

19990069924 Hernandez Engineering, Inc., Huntsville, AL USA

Beauty and The Beast: Use and Abuse of the Fault Tree as a Tool

Long, R. Allen, Hernandez Engineering, Inc., USA; 1999; 10p; In English; Systems Safety, 16-21 Aug. 1999, Orlando, FL, USA
Contract(s)/Grant(s): NAS8-40364; No Copyright; Avail: Issuing Activity, Hardcopy

Fault Tree Analysis (FTA) has become a popular tool for use in the Space Industry for the System Safety Engineer. The fault tree is used for everything from tracking hazard reports to investigating accidents, as well as presentations to management. Yet, experience in the space industry has shown the fault tree is used most often for purposes other than its original intent, namely for evaluating inappropriate behavior in complex systems. This paper describes proper application and common misapplications of the fault tree as a tool when evaluating inappropriate behavior in complex systems. The paper addresses common misconceptions and pitfalls about FTA such as tracking only failures, and the belief that Failure Modes and Effects Analysis (FMEA) can be used in lieu of the fault tree.

Author

Failure Analysis; Trees (Mathematics); Complex Systems

19990074063

How to use FMEA to reduce the size of your quality toolbox

Vandenbrande, Willy W., Quality Solutions Consult, Belgium; Quality Progress; Nov, 1998; ISSN 0033-524X; Volume 31, no. 11, pp. 97-100; In English; Copyright; Avail: Issuing Activity

The failure mode effects analysis (FMEA) has been proven to be a useful and powerful tool in assessing potential failures and preventing them from occurring. When introducing a new process, the classical process FMEA can easily be adapted to the study of potential environmental risks. Using a new table for scoring severity, the environmental priority number can be calculated in the same way as the risk priority number. The scoring table is specifically designed to assess the severity of the environmental

impact related to a failure mode/cause combination. Occurrence and detection are scored in exactly the same way as in the FMEA process.

EI

Failure Analysis; Failure Modes; Assessments; Risk; Environmental Surveys; Computation; Quality Control

20000003053 Condition Monitoring and Diagnostic Engineering Management International, Birmingham, UK

Mechanical Failure Technology: A Historical Perspective

Pusey, Henry C., Society for Machinery Failure Prevention Technology, USA; International Journal of COMADEM; 1998; ISSN 1363-7681; Volume 1, No. 4, pp. 25-33; In English; Copyright; Avail: Issuing Activity, Hardcopy

This paper provides a general overview of developments and progress in mechanical failure prevention technology, primarily over the last three decades. It is an updated version of a paper published in the proceedings of the 50th meeting of the MFPT Society. Still earlier, a longer version was presented at a luncheon of the Reliability, Stress Analysis and Failure Prevention Committee at the 1995 ASME Design Engineering Technical Conferences in Boston, Massachusetts. The principal reference sources used are the proceedings of the 52 conferences of the Society for Machinery Failure Prevention Technology (MFPT) and its predecessor, the Mechanical Failures Prevention Group (MFPG). Since many technical disciplines are involved in this complex technological area, an attempt is made to place mechanical failure prevention in perspective. Discussion of the evolving technology is presented under four topic areas that serve to cover most of the elements of this broad-based field. These topics are Diagnostics and Prognostics, Failure Analysis, Life Extension and Durability, and Sensors Technology; the topics were selected because they also represent areas covered by four technical committees of the MFPT Society.

Author

Dynamic Structural Analysis; Failure Analysis; Failure Modes; Maintenance; Prevention; Reliability Analysis

39

STRUCTURAL MECHANICS

Includes structural element design, analysis and testing; dynamic responses of structures; weight analysis; fatigue and other structural properties; and mechanical and thermal stresses in structure. For applications see 05 Aircraft Design, Testing and Performance and 18 Spacecraft Design, Testing and Performance.

19710019116

Proceedings of the 10th Meeting of the Mechanical Failures Prevention Group

Sawyer, W. T.; Apr 13, 1971; 44p; In English

Contract(s)/Grant(s): N00014-69-C-0108

Report No.(s): AD-721912; MFPG-4; Avail: AVAIL- NTIS

Proceedings of conference on mechanical failures prevention

CASI

Conferences; Failure Analysis; Failure Modes

19730007214 Lockheed-Georgia Co., Marietta, GA, USA

Development of an understanding of the fatigue phenomena of bonded with bolted joints in advanced filamentary composite materials. Volume 3: Fatigue analysis and fatigue mode studies *Final Technical Report, Aug. 1970 - Apr. 1972*

Fehrle, A. C., Lockheed-Georgia Co., USA; Carroll, J. R., Lockheed-Georgia Co., USA; Freeman, S. M., Lockheed-Georgia Co., USA; Jun 1, 1972; 269p; In English

Contract(s)/Grant(s): F33615-70-C-1302; AF PROJ. 4364

Report No.(s): AD-750134; LGR-ER-11319-VOL-3; AFFDL-TR-72-64-VOL-3; Avail: CASI; A12, Hardcopy; A03, Microfiche

The report presents the results of the empirical program undertaken to increase the basic understanding of the fatigue phenomena of advanced composite joints. Four basic design concepts were evaluated and include both bonded and mechanically fastened joints. A broad spectrum of joint geometry variations and loading conditions are included to identify the significant parameters affecting the fatigue endurance of composite joints. Test data and analyses are included for constant amplitude testing and program fatigue loading. Realistic spectrum and block spectrum data are evaluated using Miners Cumulative Damage Theory. In conjunction with other analyses and evaluations, failure mode studies were conducted on the fracture surface of failed specimens. Scanning electron microscope (SEM) photomicrographs were used for this failure study.

CASI

Bolted Joints; Bonding; Composite Materials; Failure Analysis; Failure Modes; Fatigue (Materials)

19830024937 ESDU International Ltd., London, UK

Failure modes of fibre reinforced laminates

Oct 1, 1982; ISSN 0141-4097; 12p; In English

Report No.(s): ESDU-82025; ISBN 0-85679-405-8; Avail: ESDU, Unavail. Microfiche

This Data Item is available as part of the ESDU Sub-series on Structures. This report is the first of a group providing the designer with guidance on the methods currently available of assessing the likelihood of fracture in fiber reinforced laminates. The more complex behavior of such composites, when compared to usual metallic materials, requires an appreciation of the modes in which failure may occur before quantitative strength assessments can be made. Guidance is provided on the current knowledge of these modes for laminates comprised of continuous fiber reinforced layers. The failure modes for individual layers in the laminate under simple loading are first dealt with and they are then related to the behavior of multidirectional (layer) laminates under simple and complex loading. The modes are presented in a clear tabular form supported by notes, examples and illustrations. B.W.

Failure Analysis; Failure Modes; Laminates; Reinforcing Fibers

19830026104 Texas Univ., Dept. of Civil Engineering., Austin, TX, USA

Behavior of a high-strength concrete model subjected to biaxial compression *Annual Report, 15 Jun. 1981 - 31 Dec. 1982*

Herrin, J. C., Texas Univ., USA; Carrasquillo, R. L., Texas Univ., USA; Fowler, D. W., Texas Univ., USA; Dec 1, 1982; 148p; In English

Contract(s)/Grant(s): AF-AFOSR-0202-81

Report No.(s): AD-A126442; AFOSR-83-9137TR; Avail: CASI; A07, Hardcopy; A02, Microfiche

The stress-strain behavior, ultimate strength, and failure mechanism of high-strength concrete subjected to biaxial compression is determined. Model concrete plate specimens, composed of nine aggregate discs embedded in a mortar matrix, were used. Three different coarse aggregates together with three different mortar mixes having different strength and elastic properties were used in order to determine the effects of material properties on the behavior of high-strength concrete subjected to biaxial compression. The plate specimens were tested using four biaxial stress ratios: 0 (uniaxial), 0.2, 0.5, and 1.0. Deformations in both the major and minor principal directions were measured using direct current differential transducers. Stress-strain characteristics, discontinuity, ultimate strength and failure modes in biaxial compression as a function of materials properties are discussed.

DTIC

Axial Compression Loads; Concretes; Failure Analysis; Failure Modes; Stress-Strain Relationships

19840021179 NASA Lewis Research Center, Cleveland, OH, USA

Mode 2 fatigue crack growth specimen development

Buzzard, R. J., NASA Lewis Research Center, USA; Gross, B., NASA Lewis Research Center, USA; Srawley, J. E., NASA Lewis Research Center, USA; Jan 1, 1983; 18p; In English; 17th; Natl. Symp. on Fracture Mech., 7-9 Aug. 1984, Albany, NY, USA; Sponsored by Am. Soc. for Testing and Mater.

Contract(s)/Grant(s): RTOP 505-33-22

Report No.(s): NASA-TM-83722; E-2108; NAS 1.15:83722; Avail: CASI; A03, Hardcopy; A01, Microfiche

A Mode II test specimen was developed which has potential application in understanding phenomena associated with mixed mode fatigue failures in high performance aircraft engine bearing races. The attributes of the specimen are: it contains one single ended notch, which simplifies data gathering and reduction; the fatigue crack grows in-line with the direction of load application; a single axis test machine is sufficient to perform testing; and the Mode I component is vanishingly small.

CASI

Aircraft Engines; Bearings; Crack Propagation; Cyclic Loads; Failure Analysis; Failure Modes; Notch Tests; Specimen Geometry

19860018208 NASA Lewis Research Center, Cleveland, OH, USA

Re-examination of cumulative fatigue damage analysis: An engineering perspective

Manson, S. S., NASA Lewis Research Center, USA; Halford, G. R., NASA Lewis Research Center, USA; Jan 1, 1986; 71p; In English; Symposium on Mechanics of Damage and Fatigue, 1-5 Jul. 1985, Haifa-Tel Aviv, Israel; Sponsored by International Union of Theoretical and Applied Mechanics

Contract(s)/Grant(s): RTOP 553-13-00

Report No.(s): NASA-TM-87325; E-3066; NAS 1.15:87325; Avail: CASI; A04, Hardcopy; A01, Microfiche

A method which has evolved in our laboratories for the past 20 yr is re-examined with the intent of improving its accuracy and simplicity of application to engineering problems. Several modifications are introduced both to the analytical formulation of the Damage Curve Approach, and to the procedure for modifying this approach to achieve a Double Linear Damage Rule

formulation which immensely simplifies the calculation. Improvements are also introduced in the treatment of mean stress for determining fatigue life of the individual events that enter into a complex loading history. While the procedure is completely consistent with the results of numerous two level tests that have been conducted on many materials, it is still necessary to verify applicability to complex loading histories. Caution is expressed that certain phenomena can also influence the applicability - for example, unusual deformation and fracture modes inherent in complex loading - especially if stresses are multiaxial. Residual stresses at crack tips, and metallurgical factors are also important in creating departures from the cumulative damage theories; examples of departures are provided.

CASI

Crack Tips; Damage Assessment; Deformation; Failure Analysis; Failure Modes; Fatigue Life; Life (Durability); Palmgren-Miner Rule

19860058828 NASA Lewis Research Center, Cleveland, OH, USA

Mode II fatigue crack growth specimen development

Buzzard, R. J., NASA Lewis Research Center, USA; Gross, B., NASA Lewis Research Center, USA; Srawley, J. E., NASA Lewis Research Center, USA; Jan 1, 1986; 18p; In English; See also A86-43551; Copyright; Avail: Issuing Activity

A Mode II test specimen was developed which has potential application in understanding phenomena associated with mixed mode fatigue failures in high performance aircraft engine bearing races. The attributes of the specimen are: it contains one single ended notch, which simplifies data gathering and reduction; the fatigue crack grows in-line with the direction of load application; a single axis test machine is sufficient to perform testing; and the Mode I component is vanishingly small.

AIAA

Aircraft Engines; Bearings; Crack Propagation; Cyclic Loads; Failure Analysis; Failure Modes; Notch Tests; Specimen Geometry

19870020452 Oak Ridge Gaseous Diffusion Plant, Enrichment Technology Applications Center., TN, USA

Compression failure of graphite/epoxy rings under strain control loading

Blake, H. W., Oak Ridge Gaseous Diffusion Plant, USA; Jun 1, 1987; 8p; In English

Contract(s)/Grant(s): DE-AC05-84OT-21400

Report No.(s): DE87-012036; K/ETAC-5; CONF-8709112-1; Avail: CASI; A02, Hardcopy; A01, Microfiche

Composite rings of several graphite/epoxy materials were subjected to external pressure in a test fixture designed to provide strain control. The fixture suppresses the structural buckling modes of failure of the ring thus permitting thinner rings to be tested to their material strength limit without instability. Several failure modes are identified, and results for two materials are compared with tests on the same materials using flat specimens.

DOE

Compression Tests; Failure Analysis; Failure Modes; Compressing; Failure; Graphite-Epoxy Composites

19870034854 Case Western Reserve Univ., Cleveland, OH, USA

Re-examination of cumulative fatigue damage analysis - An engineering perspective

Manson, S. S., Case Western Reserve University, USA; Halford, G. R., NASA Lewis Research Center, USA; Engineering Fracture Mechanics; Jan 1, 1986; ISSN 0013-7944; 25, 5-6., pp. 539-571; In English; Previously announced in STAR as N86-276; Copyright; Avail: Issuing Activity

A method which has evolved in the laboratories for the past 20 yr is re-examined with the intent of improving its accuracy and simplicity of application to engineering problems. Several modifications are introduced both to the analytical formulation of the Damage Curve Approach, and to the procedure for modifying this approach to achieve a Double Linear Damage Rule formulation which immensely simplifies the calculation. Improvements are also introduced in the treatment of mean stress for determining fatigue life of the individual events that enter into a complex loading history. While the procedure is completely consistent with the results of numerous two level tests that have been conducted on many materials, it is still necessary to verify applicability to complex loading histories. Caution is expressed that certain phenomenon can also influence the applicability - for example, unusual deformation and fracture modes inherent in complex loading especially if stresses are multiaxial. Residual stresses at crack tips, and metallurgical factors are also important in creating departures from the cumulative damage theories; examples of departures are provided.

AIAA

Crack Tips; Damage Assessment; Deformation; Failure Analysis; Failure Modes; Fatigue Life; Life (Durability); Palmgren-Miner Rule

19880018194 Purdue Univ., West Lafayette, IN, USA

Failure analysis of laminated composite angles

Kelly, Scott Roger, Purdue Univ., USA; Jan 1, 1987; 140p; In English; Avail: Univ. Microfilms Order No. DA8729751, Unavail. Microfiche

Laminated angles were studied to determine the failure mechanics. Analysis was performed using the finite element method. Additionally, several alternative analysis techniques were developed based on a strength of materials approach. Tests were conducted to obtain failure data for several different angle laminate stacking sequences. Specimens were fabricated using both graphite/epoxy and fiberglass/epoxy material systems. Two different failure modes, in-plane failure and out-of-plane, or delamination, failure, were found to occur in the angle laminate. Failure analysis was conducted using the Hill criterion, the Hill-Tsai criterion and the maximum radial stress criterion. The Hill-Tsai and maximum radial stress criteria were used together to predict in-plane and out-of-plane failures respectively. The Hill criterion was used to predict failure by either failure mode. Fracture mechanics analysis was utilized to study the relationship between in-plane and out-of-plane failure. It was determined that fracture mechanics could be used to predict the onset of delamination based on the branching of in-plane bending cracks. Finally, adhesive plies were studied as a means of preventing delamination in the curved laminate.

Dissert. Abstr.

Delaminating; Failure Analysis; Failure Modes; Fracture Mechanics; Graphite-Epoxy Composites; Performance Prediction

19880034110

Post-failure analysis of bolted composite joints in tension or shear-out mode failure

Chang, Fu-Kuo; Chang, Kuo-Yen, Stanford University, USA; Journal of Composite Materials; Sep 1, 1987; ISSN 0021-9983; 21, pp. 809-833; In English; Copyright; Avail: Issuing Activity

A progressive damage model was developed for bolted joints in laminated composites which may fail in either tension mode or shear-out mode. The model is capable of assessing damage accumulated in laminates with arbitrary ply orientations during mechanical loading and of predicting the ultimate strength of the joints which failed in tension or shear-out mode. The model consists of two parts, namely, the stress analysis and the failure analysis. Stresses and strains in laminates were analyzed on the basis of the theory of finite elasticity with the consideration of material and geometric nonlinearities. Damage accumulation in laminates was evaluated by the proposed failure criteria combined with a proposed property degradation model. Based on the model, a nonlinear finite element code was developed. Numerical results were compared with available experimental data. An excellent agreement was found between the analytical predictions and the experimental data.

AIAA

Bolted Joints; Failure Analysis; Failure Modes; Laminates; Loads (Forces); Ply Orientation

19880049784

Failure criteria for composite materials governed by matrix and interface

Zhang, Ruguang; Xu, Shoubo, Shanghai GRP Research Institute, USA; Jan 1, 1987; 8p; In English; 6th; 2nd; International Conference on Composite Materials, July 20-24, 1987, London, UK; See also A88-36851; Copyright; Avail: Issuing Activity

A failure theory governed by matrix and interface failure is presented. It also reveals how the properties of constituents and adhesion of interface may affect the strength. The theoretical predictions of off-axis tensile strengths agree well with experimental results.

AIAA

Composite Materials; Failure Analysis; Failure Modes; Isotropic Media; Tensile Strength

19880058004

Failure in composite angle structures. I - Initial failure. II - Onset of delamination

Sun, C. T.; Kelly, S. R., Purdue University, USA; Journal of Reinforced Plastics and Composites; May 1, 1988; ISSN 0731-6844; 7, pp. 220-232; In English; Research supported by Purdue University; Copyright; Avail: Issuing Activity

An experimental analysis of failure in composite angle structures was performed using both the Hill (1948) and an augmented Hill-Tsai (1968) failure criteria. Depending on the layup, it was noted that some laminates could fail in delamination without experiencing transverse matrix cracking. In the second part, fracture mechanics techniques were used to study delamination cracks in composite angle structures. The results suggest that the use of adhesive films could improve the load-carrying capacity of composite angle structures.

AIAA

Bend Tests; Composite Structures; Failure Analysis; Failure Modes; Glass Fibers; Graphite-Epoxy Composites

19890029757

Distributed damage in composites, theory and verification

Frantziskonis, G., Salonika, University, Greece; Composite Structures; Jan 1, 1988; ISSN 0263-8223; 10, 2, 19; 20p; In English; Copyright; Avail: Issuing Activity

A model that accounts for the effect of structural changes, resulting from the application of loads, in composite materials, is developed. Such changes are incorporated in the theory through a tensor form of a damage variable. The model extends the theory of elasticity, and it accounts for certain important properties observed in composite materials. The parameters involved in the theory are identified and determined from available experimental data. Back prediction of test results, for two different composite materials, verifies the theory.

AIAA

Composite Materials; Damage Assessment; Failure Analysis; Failure Modes; Laminates; Structural Analysis

19900012100 Stevens Inst. of Tech., Hoboken, NJ, USA

Development of a fracture analysis technique for use with a general-purpose finite element program

Cordes, Jennifer, Stevens Inst. of Tech., USA; Jan 1, 1989; 140p; In English; Avail: Univ. Microfilms Order No. DA9001129, Unavail. Microfiche

A fracture-critical analytical model was developed and tested for prediction of failure in structural components. The analytic model creates a fictitious crack region adjacent to an actual crack or notch and uses finite element analysis to predict actual crack initiation, crack growth, and ultimate failure of the component. Unlike other approaches, this model: (1) predicts directly the loading condition causing failure in a structural component; (2) predicts failure in either a brittle or a ductile material; and (3) predicts the mode of failure (yielding or fracture) in a ductile material. The method was developed for use with a general-purpose finite element program. The fictitious crack model is based upon the Dugdale and Barenblatt damage zone models. In the fictitious crack model, the damage zone is represented by cohesive forces which act along surfaces at the crack front. As the applied load is increased, the size of the damage zone increases and the overall stiffness of the structure decreases. When the maximum load on the structure is reached, unstable crack growth occurs and the cohesive forces go to zero. In the finite element model, the cohesive forces are represented by nonlinear springs. The springs provide the material nonlinearities associated with a growing damage zone. Geometric nonlinearities associated with the large strain at the crack tip can also be included in the analysis. The analytical model was tested by comparing predicted results to experimental results described in the literature. In general, predicted results were within 12 percent of experimental failure loads for an aluminum late with a central precrack, an aluminum plate with a center hole and radial cracks, a graphite/epoxy plate with a center hole, a graphite/epoxy beam with a center crack, and a glass/epoxy with a matrix crack.

CASI

Crack Propagation; Failure Analysis; Failure Modes; Finite Element Method; Fracture Mechanics; Mathematical Models; Performance Prediction; Structural Design

19900019334 Pratt and Whitney Aircraft, West Palm Beach, FL, USA

Probabilistic model for fracture mechanics service life analysis

Annis, Charles, Pratt and Whitney Aircraft, USA; Watkins, Tommie, Pratt and Whitney Aircraft, USA; NASA, Marshall Space Flight Center, Advanced Earth-to-Orbit Propulsion Technology 1988, Volume 1; Sep 1, 1988, pp. p 653-659; In English; See also N90-28611 23-20

Contract(s)/Grant(s): NAS8-36901; Avail: CASI; A02, Hardcopy; A10, Microfiche

The service longevity of complex propulsion systems, such as the Space Shuttle Main Engine (SSME), can be at risk from several competing failure modes. Conventional life assessment practice focuses upon the most severely life-limited feature of a given component, even though there may be other, less severe, potential failure locations. Primary, secondary, tertiary failure modes, as well as their associated probabilities, must also be considered. Furthermore, these probabilities are functions of accumulated service time. Thus a component may not always succumb to the most severe, or even the most probable failure mode. Propulsion system longevity must be assessed by considering simultaneously the actions of, and interactions among, life-limiting influences. These include, but are not limited to, high frequency fatigue (HFF), low cycle fatigue (LCF), and subsequent crack propagation, thermal and acoustic loadings, and the influence of less-than-ideal nondestructive evaluation (NDE). An outline is provided for a probabilistic model for service life analysis, and the progress towards its implementation is reported.

CASI

Failure Analysis; Failure Modes; Fracture Mechanics; Mathematical Models; Prediction Analysis Techniques; Service Life; Structural Analysis

19900061943

Analysis of failures in aircraft structures

Peel, C. J.; Jones, A., Royal Aerospace Establishment, UK; Metals and Materials; Aug 1, 1990; ISSN 0266-7185; 6, pp. 496-502; In English; Copyright; Avail: Issuing Activity

Failure of a structural aircraft component can have catastrophic consequences, with the resulting loss of the whole aircraft and many lives. The investigation of defects and failures in aircraft structures is thus of vital importance in preventing aircraft disasters. This article uses detailed examples to illustrate the various methods used in the quantitative analysis of service failures in aircraft structures.

AIAA

Aircraft Accidents; Aircraft Structures; Failure Analysis; Failure Modes; Metal Fatigue; Stress Corrosion Cracking

19910000996 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, USA

Probabilistic failure assessment with application to solid rocket motors

Jan, Darrell L., Jet Propulsion Lab., California Inst. of Tech., USA; Davidson, Barry D., Jet Propulsion Lab., California Inst. of Tech., USA; Moore, Nicholas R., Jet Propulsion Lab., California Inst. of Tech., USA; NASA, Langley Research Center, Research in Structures, Structural Dynamics and Materials, 1990; Mar 1, 1990, pp. p 115-121; In English; See also N91-10301 01-39; Sponsored in part by Air Force Astronautics Lab., Edwards AFB, CA; Avail: CASI; A02, Hardcopy; A03, Microfiche

A quantitative methodology is being developed for assessment of risk of failure of solid rocket motors. This probabilistic methodology employs best available engineering models and available information in a stochastic framework. The framework accounts for incomplete knowledge of governing parameters, intrinsic variability, and failure model specification error. Earlier case studies have been conducted on several failure modes of the Space Shuttle Main Engine. Work in progress on application of this probabilistic approach to large solid rocket boosters such as the Advanced Solid Rocket Motor for the Space Shuttle is described. Failure due to debonding has been selected as the first case study for large solid rocket motors (SRMs) since it accounts for a significant number of historical SRM failures. Impact of incomplete knowledge of governing parameters and failure model specification errors is expected to be important.

CASI

Failure; Failure Analysis; Failure Modes; Space Shuttle Boosters; Space Shuttle Main Engine; Stochastic Processes

19910032759

A study on longitudinal compressive strength of FRP-composites

Xue, Yuan-De, Tongji University, USA; Wang, Zheng-Ying, Shanghai GRP Research Institute, USA; Jan 1, 1989; 13p; In English; 5th; International Conference, July 24-26, 1989, Paisley; See also A91-17376; Copyright; Avail: Issuing Activity

Failure modes of unicomposites under longitudinal compressive stress are investigated, and the compressive stress-strain curves of various types of fiber-reinforced plastic (FRP) composites are estimated. A three-dimensional model composed of a fiber embedded in a matrix is employed, assuming that the displacement continuity of two neighboring elements is constant, and a new formula for predicting FRP-longitudinal compressive strength is derived. Techniques for improving the compressive testing method are proposed, including specimen forms and loading and transverse supporting fixtures. Theoretical predictions of the compressive failure mode are verified against experimental results.

AIAA

Compression Loads; Failure Analysis; Failure Modes; Fiber Composites; Reinforced Plastics

19910046995 State Univ. of New York, Buffalo, NY, USA

Reliability analysis of continuous fiber composite laminates

Thomas, David J., State Univ. of New York, USA; Wetherhold, Robert C., New York, State University, USA; Composite Structures; Jan 1, 1991; ISSN 0263-8223; 17, 4, 19; 17p; In English
Contract(s)/Grant(s): NAG3-862; Copyright; Avail: Issuing Activity

This paper describes two methods, the maximum distortion energy (MDE) and the principle of independent action (PIA), developed for the analysis of the reliability of a single continuous composite lamina. It is shown that, for the typical laminated plate structure, the individual lamina reliabilities can be combined in order to produce the upper and the lower bounds of reliability for the laminate, similar in nature to the bounds on properties produced from variational elastic methods. These limits were derived for both the interactive and the model failure considerations. Analytical expressions were also derived for the sensitivity of the reliability limits with respect to changes in the Weibull parameters and in loading conditions.

AIAA

Failure Analysis; Failure Modes; Fiber Composites; Graphite-Epoxy Composites; Laminates; Reliability Analysis

19910048058

Local delamination buckling in layered systems

Madenci, E., Arizona, University, USA; Westmann, R. A., California, University, USA; ASME, Transactions, Journal of Applied Mechanics; Mar 1, 1991; ISSN 0021-8936; 58, pp. 157-166; In English

Report No.(s): ASME PAPER 90-WA/APM-40; Copyright; Avail: Issuing Activity

This paper presents an analytical solution to the problem of local buckling induced by delamination of a layered plate. Delamination growth and buckling is an observed failure mode in laminated structures subjected to compressive loads. Previous analytical studies of the phenomenon rest upon simplifying structural and geometric approximations. The purpose of this paper is to present solutions for this problem using the classical three-dimensional theory of elasticity to predict the buckled equilibrium state. Solutions to the problem of a plate with a circular delamination subjected to axisymmetric and uniaxial in-plane compressive loadings are obtained using mathematical techniques appropriate for mixed boundary value problems.

AIAA

Buckling; Delaminating; Failure Analysis; Failure Modes; Laminates

19910053231

Failure characteristics in thermoplastic composite laminates due to an eccentric circular discontinuity

Daniels, J. A.; Palazotto, A. N., USAF, Institute of Technology, Wright-Patterson AFB, USA; Sandhu, R. S., USAF, Wright Research and Development Center, USA; AIAA Journal; May 1, 1991; ISSN 0001-1452; 29, pp. 830-837; In English; Previously cited in issue 11, p. 1700, Accession no. A90-29353; Avail: Issuing Activity

No abstract.

Failure Analysis; Failure Modes; Graphite-Epoxy Composites; Laminates; Stress-Strain Diagrams; Thermoplastic Resins

19920042260

Reliability analysis method for reinforced frame structures

Song, Bifeng; Feng, Yuansheng, Northwestern Polytechnical University, USA; Northwestern Polytechnical University, Journal; Jan 1, 1992; ISSN 1000-2758; 10, pp. 95-102; In Chinese; In Chinese; Avail: Issuing Activity

An improved technique is proposed to reduce the probability of failing to enumerate the significant failure modes in a structural fault tree. The reliability analysis model of a type of large scale structure (reinforced frame structure) is established by means of the finite element model corresponding to the structure. Examples are given to confirm the efficiency of the methodology and the reliability analysis model.

AIAA

Failure Analysis; Failure Modes; Reliability Analysis; Structural Analysis

19920050150

Nonlinear analysis of propagation of delamination near free edges

Schellekens, J. C. J.; De Borst, R., Delft University, Netherlands; Jan 1, 1991; 11p; In English; 8th; International Conference on Composite Materials (ICCM/8), July 15-19, 1991, Honolulu, HI, USA; Sponsored by SAMPE; See also A92-32535; Avail: Issuing Activity

The free-edge delamination of a graphite-epoxy composite is analyzed using a fully nonlinear finite element approach that accounts for thermal and hygroscopic effects. For this purpose, a mode-I crack model including strain softening is developed. Results obtained from the analysis of (+25n/-25n/90n)s laminates were found to be in good agreement with experimental observations. It is shown that the new approach does not suffer from mesh dependency, implying that size effects can be described properly.

AIAA

Delaminating; Failure Analysis; Failure Modes; Fracture Mechanics; Graphite-Epoxy Composites; Plane Strain

19920050169

A criterion for the delamination of composite laminates

Du, Shanyi; Yan, Xiangqiao; Wang, Duo, Harbin Institute of Technology, USA; Jan 1, 1991; 6p; In English; 8th; International Conference on Composite Materials (ICCM/8), July 15-19, 1991, Honolulu, HI, USA; Sponsored by SAMPE; See also A92-32535; Avail: Issuing Activity

In this paper, the mixed-mode fracture criterion of the delamination onset of composite laminates was presented. Using this criterion, it is expected that the failures of various composite laminates whose major failure mode is delaminated can be analyzed.

AIAA

Delaminating; Failure Analysis; Failure Modes; Fracture Mechanics; Laminates

19920050200

On the finite-strain-invariant failure criterion for composites

Feng, William W.; Groves, Scott E., Lawrence Livermore National Laboratory, USA; Jan 1, 1991; 8p; In English; 8th; International Conference on Composite Materials (ICCM/8), July 15-19, 1991, Honolulu, HI, USA; Sponsored by SAMPE; See also A92-32535

Contract(s)/Grant(s): W-7405-ENG-48; Avail: Issuing Activity

The finite-strain-invariant failure criterion developed by Feng is being evaluated with the experimental data for a boron/epoxy, symmetrically balanced, angle-ply laminate. The results indicate that the failure-criterion prediction agrees with the experimental data and that the failure criterion also predicts the matrix-dominated or fiber-dominated modes of failure. Two special isotropic cases in infinitesimal strain theory are obtained. The failure criteria for these special cases preserve the mathematical forms of both the generalized Von Mises yield criterion and the Von Mises yield criterion in plasticity.

AIAA

Boron-Epoxy Composites; Failure Analysis; Failure Modes; Finite Element Method; Stress Analysis

19920050249

Generators of MIL-HDBK-5 design allowables for ARALL laminates

Wu, H. F.; Bucci, R. J.; Wygonik, R. H., Alcoa Laboratories, Alcoa Center, USA; Rice, Richard, Battelle Laboratories, USA; Jan 1, 1991; 12p; In English; 8th; International Conference on Composite Materials (ICCM/8), July 15-19, 1991, Honolulu, HI, USA; Sponsored by SAMPE; See also A92-32535; Avail: Issuing Activity

Attention is given to a complex statistical experimental design consisting of three aluminum alloy production lots and five prepreg lots. Two types of surface treatments for the alloy sheet, chromic acid, and phosphoric acid anodizing are investigated. All laminations were cured under four time/temperature autoclave cycles. The overall procedures for developing static design allowables of ARALL laminates, a family of laminated hybrid composite structural sheet materials featuring high strength, low density, and high resistance to fatigue and fracture, are presented. A modified MIL-HDBK-5E method is used to statistically reduce test data for providing S-basis material properties for tension, compression, in-plane shear, and bearing. The failure modes of the specimens for each test are examined and described.

AIAA

Aluminum Alloys; Epoxy Resins; Failure Analysis; Failure Modes; Fiber Composites; Hybrid Structures; Laminates

19920065047

Approximate analysis for failure probability of structural systems

Cai, Yin-Lin; Zhou, Jian-Sheng, Harbin Shipbuilding Engineering Institute, USA; Acta Aeronautica et Astronautica Sinica; Mar 1, 1992; ISSN 1000-6893; 13, 3, Ma, pp. A219-A22; In Chinese; In Chinese; Avail: Issuing Activity

An approximate formula for calculating failure probability of structural systems is presented, which uses the lower and upper bounds of the first simple bounds to estimate the failure probability. In this formula, the correlation between each of the two failure modes of a structure is considered, but only the first failure probability of the failure modes is contained. Computations using the approximate formula are quite simple and accurate, with maximum error being within 5 percent.

AIAA

Approximation; Failure Analysis; Failure Modes; Probability Theory; Structural Failure

19920065997

Damage mechanisms in CFK laminates - Analysis by tests and calculations *Schadensmechanismen in CFK-Laminaten - Analyse durch Tests und Berechnungen*

Eggers, Hans, DLR, Institut fuer Strukturmechanik, Braunschweig, USA; DLR-Nachrichten; May 1, 1992; ISSN 0937-0420, 67, M, pp. 2-7; In German; In German; Copyright; Avail: Issuing Activity

Models and computer programs for analyzing damage mechanisms in CFK composites are discussed. The modeling of individual cracks is examined and sample results are presented.

AIAA

Carbon Fiber Reinforced Plastics; Failure Analysis; Failure Modes; Fault Tolerance; Laminates

19920068236

Failure analysis and reliability improvement of small turbine engine blades

Shee, H. K.; Chen, H. Y.; Yang, T. W., Chung Shan Institute of Science and Technology, USA; Engineering Fracture Mechanics; Jul 1, 1992; ISSN 0013-7944; 42, 5, Ju; 12p; In English; Copyright; Avail: Issuing Activity

Analysis and testing procedures for small turbine engines are presented which are aimed at verifying the critical failure modes and improving the performance, reliability, and safety of operating engine blades. These procedures include metallographic examination; chemical ingredient, vibration, modal, and stress analyses; fatigue life prediction; and modal testing with and without coating. It is demonstrated that, for small turbine engine under consideration, the most probable failure mode is the fatigue fracture rather than the creep fracture. An approach based on the reduction of the number of stators from 17 to 14 is found to be the most beneficial for improving the fatigue performance and reliability of engine blades as compared to the surface coating and high strength material approaches. This approach removes vibrational frequencies of the turbine engine from the operating frequencies, thus significantly reducing the vibrational level of engine blades.

AIAA

Failure Analysis; Failure Modes; Reliability Engineering; Structural Vibration; Turbine Blades

19920075872 Northrop Corp., Aircraft Div., Hawthorne, CA, USA

Static strength prediction of composite single fastener joints

Agarwal, B. L., Northrop Corp., USA; Sep 1, 1977; 27p; In English

Report No.(s): NOR-77-126; Avail: CASI; A03, Hardcopy, Unavail. Microfiche

A new analytical method of predicting the strength of double shear single fastener composite joints is presented. The analysis method consists of calculating the stress distribution around a fastener hole using a finite element analysis and predicting the various modes of joint failure through the use of the average stress failure criterion. The basic laminate strength is predicted by maximum strain theory. The analytical predictions are compared with the available experimental data.

CASI

Bearings; Bolted Joints; Bolts; Composite Materials; Failure Analysis; Failure Modes; Fasteners; Finite Element Method; Holes (Mechanics); Laminates; Prediction Analysis Techniques; Stress Analysis; Stress Distribution

19930001317 Chung Shan Inst. of Science and Technology, Taichung, Taiwan

Failure analysis of laminated composites by using iterative three-dimensional finite element method

Hwang, W. C., Chung Shan Inst. of Science and Technology, Taiwan; Sun, C. T., Chung Shan Inst. of Science and Technology, Taiwan; Carleton Univ., Proceedings of the Twelfth Canadian Congress of Applied Mechanics, Volumes 1 and 2; May 1, 1989, pp. p 314-315; In English; See also N93-10466 01-31; Copyright; Avail: Issuing Activity (Canadian Society for Mechanical Engineering, 2050 Mansfield St., Suite 700, Montreal, Quebec H3A 1Z7 Canada), Unavail. Microfiche

A failure analysis of laminated composites is accomplished by using an iterative three-dimensional finite element method. Based on Tsai-Wu failure theory, three different modes of failure are proposed: fiber breakage, matrix cracking, and delamination. The first ply failure load is then evaluated. As the applied load exceeds the first ply failure load, localized structural failure occurs and the global structural stiffness should change. The global stiffness matrix is modified by taking nonlinearity due to partial failures within a laminate into consideration. The first ply failure load is analyzed by using a iterative mixed field method in solving the linear part of the finite element equations. The progressive failure problem is solved numerically by using Newton-Raphson iterative schemes for the solution of nonlinear finite element equations. Numerical examples include angle-ply symmetric Thorne 300 graphite/934 resin epoxy laminates under uniaxial tension. First ply failure loads as well as the final failure loads are evaluated. Good correlation between analytical results and experimental data are observed. Numerical results also include the investigation of composite specimens with a centered hole, under uniaxial tension. Excellent correlation with the experimental data is observed. Author (CISTD)

Composite Materials; Critical Loading; Failure Analysis; Failure Modes; Finite Element Method; Laminates; Nonlinearity

19930004970 Georgia Inst. of Tech., Atlanta, GA, USA

Analysis of advanced thin-walled composite structures

Badir, Ashraf M., Georgia Inst. of Tech., USA; Jan 1, 1992; 146p; In English; Avail: Univ. Microfilms Order No. DA9223766, Unavail. Microfiche

The use of fiber reinforced composites is increasing in engineering applications. One of the major issues is composite structures in the understanding of the role of the material's anisotropy on the deformation modes, damage modes and failure mechanisms. This research work addresses these stiffness and strength related issues by developing analytical models for the prediction of deformation modes and their coupling effects and damage onset and growth in laminated composites. Accurate

prediction of stiffness, response, damage modes and failure mechanisms is bound to lead to the design of efficient and damage tolerant composite structures. In the first part of this work shear deformation models including hygrothermal effects are developed for the analysis of mid-plane edge delamination and local delamination originating from transverse cracks in 90 degree plies. The results of these models are combined with a previously developed shear deformation model for mixed-mode edge delamination to yield a unified analysis of delamination and the ability to identify the critical failure modes and loads. In the second part, a variationally and asymptotically consistent theory for thin-walled beams that incorporates the anisotropy associated with laminated composites is developed. The theory is based on an asymptotical analysis of 2D shell energy.

Dissert. Abstr.

Composite Structures; Critical Loading; Failure Analysis; Failure Modes; Fiber Composites; Strain Distribution; Thin Walls

19930008590 NASA Langley Research Center, Hampton, VA, USA

Transient/structural analysis of a combustor under explosive loads

Gregory, Peyton B., NASA Langley Research Center, USA; Holland, Anne D., NASA Langley Research Center, USA; Dec 1, 1992; 27p; In English

Contract(s)/Grant(s): RTOP 505-43-31-05

Report No.(s): NASA-TM-107660; NAS 1.15:107660; Avail: CASI; A03, Hardcopy; A01, Microfiche

The 8-Foot High Temperature Tunnel (HTT) at NASA Langley Research Center is a combustion-driven blow-down wind tunnel. A major potential failure mode that was considered during the combustor redesign was the possibility of a deflagration and/or detonation in the combustor. If a main burner flame-out were to occur, then unburned fuel gases could accumulate and, if reignited, an explosion could occur. An analysis has been performed to determine the safe operating limits of the combustor under transient explosive loads. The failure criteria was defined and the failure mechanisms were determined for both peak pressures and differential pressure loadings. An overview of the gas dynamics analysis was given. A finite element model was constructed to evaluate 13 transient load cases. The sensitivity of the structure to the frequency content of the transient loading was assessed. In addition, two closed form dynamic analyses were conducted to verify the finite element analysis. It was determined that the differential pressure load or thrust load was the critical load mechanism and that the nozzle is the weak link in the combustor system.

Author

Combustion Chambers; Critical Loading; Dynamic Structural Analysis; Explosions; Failure Analysis; Failure Modes; Finite Element Method; Thrust Loads; Transient Loads; Wind Tunnel Apparatus; Wind Tunnels

19930013915 NASA Marshall Space Flight Center, Huntsville, AL, USA

Preliminary analysis techniques for ring and stringer stiffened cylindrical shells

Graham, J., NASA Marshall Space Flight Center, USA; Mar 1, 1993; 104p; In English

Report No.(s): NASA-TM-108399; NAS 1.15:108399; Avail: CASI; A06, Hardcopy; A02, Microfiche

This report outlines methods of analysis for the buckling of thin-walled circumferentially and longitudinally stiffened cylindrical shells. Methods of analysis for the various failure modes are presented in one cohesive package. Where applicable, more than one method of analysis for a failure mode is presented along with standard practices. The results of this report are primarily intended for use in launch vehicle design in the elastic range. A Microsoft Excel worksheet with accompanying macros has been developed to automate the analysis procedures.

Author

Buckling; Cylindrical Shells; Design Analysis; Failure Analysis; Failure Modes; Launch Vehicles; Spacecraft Design

19930020654 Sandia National Labs., Livermore, CA, USA

An experimental/analytical evaluation of biaxial sheet failure

Lee, K. L., Sandia National Labs., USA; Brandon, S. L., Sandia National Labs., USA; Horstemeyer, M. F., Sandia National Labs., USA; Korellis, J. S., Sandia National Labs., USA; Mar 1, 1993; 26p; In English

Contract(s)/Grant(s): DE-AC04-76DR-00789

Report No.(s): DE93-010620; SAND-93-8226; Avail: CASI; A03, Hardcopy; A01, Microfiche

An experimental test system has been developed to support numerical modeling analysis of sheet metal failure. The system consists of a planar biaxial test frame, cruciform specimens and grips, and custom software to control the frame's actuators. Thin aluminum 6061-0 specimens are loaded to the point of incipient failure under different biaxial stress ratios. The data from these

tests are used in validating a constitutive plasticity/failure model for aluminum 6061-0 by comparison with finite element predictions.

DOE

Actuators; Aluminum; Axial Stress; Failure Analysis; Failure Modes; Finite Element Method; Metal Fatigue; Metal Sheets

19930036093

Heterogeneity of stresses and rupture of brittle materials *Heterogenite des contraintes et rupture des materiaux fragiles*
Hild, Francois; Billardon, Rene; Marquis, Didier, Lab. de Mecanique et Technologie, France; Academie des Sciences (Paris), Comptes Rendus, Serie II - Mecanique, Physique, Chimie, Sciences de la Terre et de l'Univers; Nov. 19, 1992; ISSN 0764-4450; 315, 11, pp. 1293-1298.; In French; Copyright; Avail: Issuing Activity

Various factors are introduced which make it possible to model the effect of stress heterogeneity on the mean rupture stress of structures made of brittle materials. It is proposed that one use the first-order moment associated with the stress distribution, $H_{sub 1}$, as the stress heterogeneity factor.

AIAA

Brittle Materials; Failure Analysis; Failure Modes; Rupturing; Stress Distribution

19930044620

Generation of MIL-HDBK-5 design allowables for aramid/aluminum laminates

Wu, H. F.; Bucci, R. J.; Wygonik, R. H., Alcoa Technical Center, USA; Rice, R. C., Battelle, USA; Journal of Aircraft; Mar.-Apr. 1993; ISSN 0021-8669; 30, 2, pp. 275-282.; In English; Previously cited in issue 13, p. 2191, Accession no. A92-32873 Composites; Proceedings of the 8th International Conference on Composite Materials /ICCM/8/, Honolulu, HI, July 15-19, 1991. Section 30-39, p. 36-P-1 to 36-P-12; Copyright; Avail: Issuing Activity

No abstract.

Aluminum Alloys; Aramid Fiber Composites; Epoxy Resins; Failure Analysis; Failure Modes; Hybrid Structures; Laminates

19940018139 Stanford Univ., Dept. of Aeronautics and Astronautics., CA, USA

Modeling of failure and response to laminated composites subjected to in-plane loads

Shahid, Iqbal, Stanford Univ., USA; Chang, Fu-Kuo, Stanford Univ., USA; NASA. Langley Research Center, Computational Methods for Failure Analysis and Life Prediction; Oct 1, 1993, pp. p 83-120; In English; See also N94-22608 05-39; Avail: CASI; A03, Hardcopy; A03, Microfiche

An analytical model was developed for predicting the response of laminated composites with or without a cutout and subjected to in-plane tensile and shear loads. Material damage resulting from the loads in terms of matrix cracking, fiber-matrix shearing, and fiber breakage was considered in the model. Delamination, an out-of-plane failure mode, was excluded from the model.

Author (revised)

Constitutive Equations; Failure Analysis; Failure Modes; Fracture Mechanics; Laminates; Stress Analysis

19940020878 Wyoming Univ., Dept. of Computer Science., Laramie, WY, USA

Failure detection and recovery in the assembly/contingency subsystem

Gantenbein, Rex E., Wyoming Univ., USA; NASA. Johnson Space Center, National Aeronautics and Space Administration (NASA)(American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1993, Volume 1 15 p (SEE N94-25348; Dec 1, 1993, pp. NASA. Johnson Space ; In English; Avail: CASI; A03, Hardcopy; A03, Microfiche

The Assembly/Contingency Subsystem (ACS) is the primary communications link on board the Space Station. Any failure in a component of this system or in the external devices through which it communicates with ground-based systems will isolate the Station. The ACS software design includes a failure management capability (ACFM) that provides protocols for failure detection, isolation, and recovery (FDIR). The the ACFM design requirements as outlined in the current ACS software requirements specification document are reviewed. The activities carried out in this review include: (1) an informal, but thorough, end-to-end failure mode and effects analysis of the proposed software architecture for the ACFM; and (2) a prototype of the ACFM software, implemented as a C program under the UNIX operating system. The purpose of this review is to evaluate the FDIR protocols specified in the ACS design and the specifications themselves in light of their use in implementing the ACFM. The basis of failure detection in the ACFM is the loss of signal between the ground and the Station, which (under the appropriate circumstances) will initiate recovery to restore communications. This recovery involves the reconfiguration of the ACS to either a backup set of components or to a degraded communications mode. The initiation of recovery depends largely on the criticality

of the failure mode, which is defined by tables in the ACFM and can be modified to provide a measure of flexibility in recovery procedures.

Author

Communication Networks; Computer Programming; Computer Programs; Data Links; Failure Analysis; Failure Modes; Protocol (Computers); Space Communication; Space Stations

19940033194 Sandia National Labs., Albuquerque, NM, USA

Numerical simulation of dynamic fracture and failure in solids

Chen, E. P., Sandia National Labs., USA; Jan 1, 1994; 4p; In English; International Symposium on Fracture and Strength of Solids, 4-8 Jul. 1994, Xian, China

Contract(s)/Grant(s): DE-AC04-94AL-85000

Report No.(s): DE94-010379; SAND-94-0247C; CONF-940771-1; Avail: CASI; A01, Hardcopy; A01, Microfiche

Numerical simulation of dynamic fracture and failure processes in solid continua using Lagrangian finite element techniques is the subject of discussion in this investigation. The specific configurations in this study include penetration of steel projectiles into aluminum blocks and concrete slabs. The failure mode in the aluminum block is excessive deformation while the concrete slab fails by hole growth, spallation, and scabbing. The transient dynamic finite element code LS-DYNA2D was used for the numerical analysis. The erosion capability in LS-DYNA2D was exercised to carry out the fracture and failure simulations. Calculated results were compared to the experimental data. Good correlations were obtained.

DOE

Aluminum; Computerized Simulation; Concretes; Erosion; Failure Analysis; Failure Modes; Finite Element Method; Fracture Mechanics; Steels

19940033288 Northrop Corp., Aircraft Div., Hawthorne, CA, USA

Effects of scale in predicting global structural response

Kan, Han-Pin, Northrop Corp., USA; Deo, R. B., Northrop Corp., USA; NASA. Langley Research Center, Workshop on Scaling Effects in Composite Materials and Structures; Jul 1, 1994, pp. p 37-46; In English; See also N94-37796 12-39

Contract(s)/Grant(s): NAS1-18842; Avail: CASI; A02, Hardcopy; A03, Microfiche

In the course of previous composite structures test programs, the need for and the feasibility of developing analyses for scale-up effects has been demonstrated. The analysis techniques for scale-up effects fall into two categories. The first category pertains to developing analysis methods independently for a single, unique failure mode in composites, and using this compendium of analysis methods together with a global structural model to identify and predict the response and failure mode of full-scale built-up structures. The second category of scale-up effects pertains to similitude in structural validation testing. In this latter category, dimensional analysis is used to develop scale-up laws that enable extrapolation of sub-scale component test data to full-scale structures. This viewgraph presentation describes the approach taken and some developments accomplished in the first category of analysis for scale-up effects. Layup dependence of composite material properties severely limits the use of the dimensional analysis approach and these limitations are illustrated by examples.

Author (revised)

Composite Structures; Failure Analysis; Failure Modes; Scale Models; Structural Analysis

19970007189 Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek, Center for Mechanical Engineering, Delft, Netherlands

The splined shafts of the YPR vehicle: A general inquiry on the material quality aspects that influence fatigue life *Final Report De steekassen van de YPR. Een algeheel onderzoek naar de verschillen in materiaalkwaliteit die de vermoeiingslevensduur beïnvloeden*

Oostvogels, J. M. J., Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek, Netherlands; Nov. 06, 1996; 25p; In Dutch Contract(s)/Grant(s): A96/KM/131

Report No.(s): RP-96-0112; TNO-96-CMC-R1438; Copyright; Avail: Issuing Activity (TNO Centre for Mechanical Engineering, Leeghwaterstraat 5, 2628 CA Delft, The Netherlands), Hardcopy, Microfiche

This report summarizes drive shaft features as tested for chemical composition, hardness, toughness, and microscopic structure to determine the mechanisms that cause metal fatigue failure.

Derived from text

Shafts (Machine Elements); Spindles; Fatigue Life; Failure Analysis; Failure Modes; Metal Fatigue

19980034715

A bilinear failure criterion for mixed-mode delamination

Reeder, James R., NASA Langley Research Center, USA; 1993, pp. 303-322; In English; Copyright; Avail: Aeroplus Dispatch

The mixed-mode bending (MMB) test was used to measure the delamination toughness of a brittle epoxy composite, a state-of-the-art toughened epoxy composite, and a tough thermoplastic composite over the full mixed-mode range. The delamination fracture surfaces were also examined. An evaluation of several failure criteria that have been reported in the literature was performed and the range of responses modeled by each criterion was analyzed. A bilinear failure criterion was introduced based on a change in the failure mechanism observed from the delamination surfaces. The different criteria were compared to the failure response of the three materials tested. The responses of the two epoxies were best modeled with the new bilinear failure criterion. The failure response of the tough thermoplastic composite could be modeled well with the bilinear criterion but could also be modeled with the more simple linear failure criterion. Since the materials differed in their mixed-mode failure response, mixed-mode delamination testing will be needed to characterize a composite material.

Author (revised by AIAA)

Failure Analysis; Delaminating; Failure Modes; Fracture Mechanics; Resin Matrix Composites

19980072647

Initial failure of mechanically fastened joints with offset loading

Falzon, B. G., Imperial College of Science, Technology and Medicine, UK; Davies, G. A. O., Imperial College of Science, Technology and Medicine, UK; Advanced Composites Letters; 1997; ISSN 0963-6935; Volume 6., no. 4, pp. 91-94; In English; Copyright; Avail: Aeroplus Dispatch

The initial failure of a bolted composite joint is investigated. The results of an experimental program using two simple beams bolted together with offset loading are presented. These test specimens were used to simulate a typical skin-spar attachment in a composite wing undergoing hydraulic shock. Initial failure is found to be due to a prying force induced at the outer sections of the joint leading to transverse shear failure.

Author (AIAA)

Bolted Joints; Failure Analysis; Beams (Supports); Wings; Failure Modes; Hydraulic Shock

19980114912

Overview of failure in composite materials

Lessard, Larry B., McGill Univ., Canada; Shokrieh, Mahmood M., McGill Univ., Canada; 1995, pp. 255-260; In English; Copyright; Avail: Aeroplus Dispatch

Composite materials exhibit very complicated failure phenomena as compared to isotropic materials. There are many failure modes which can occur, each of which is caused by a different failure mechanism. It is essential to be able to model how composite materials fail and what happens to the material after failure has occurred. The mechanisms of failure in composites can be grouped into four major categories: internal material damage due to in-plane loading, delamination, damage due to foreign object impact, and damage due to fatigue loading. Estimation of failure in any one of the above categories can be a difficult task which may depend on many variables. One must assess the parameters of each situation and be able to apply a suitable failure criterion. Composites may sustain amounts of damage and still be capable of handling load. It is important to understand failure in composite materials and the process by which the damage situation develops from initial damage to catastrophic failure.

Author (AIAA)

Composite Materials; Failure Analysis; Plane Strain; Failure Modes; Delaminating; Impact Damage

19980118121

The application of unvaried stiffness matrix method to the failure analysis of a composite laminated structural system

Zhao, Meiying, Northwestern Polytechnical Univ., China; Wan, Xiaopeng, Northwestern Polytechnical Univ., China; Northwestern Polytechnical University, Journal; Nov. 1995; ISSN 1000-2758; Volume 13, no. 4, pp. 510-513; In Chinese; Copyright; Avail: Aeroplus Dispatch

In the past decade, much research has been done on reliability analysis of a structural system. Yang (1988) presented a finite element full quantity loading method to enumerate and identify significant failure modes of composite laminated structural systems, but it is expensive to calculate the reliability of a large scale structural system. We provide an efficient method, the 'unvaried stiffness matrix' method, which can be used to deal with the failure analysis of complicated structures in economical computing time. In this method, by substituting an equivalent additional force for the rigidity effect of the failure elements, the original stiffness matrix of the structure can remain unchanged and significant failure modes of a large scale composite laminated

structural system can be enumerated by factorizing stiffness matrix only once. A composite laminate plate with a hole is taken as numerical example.

Author (AIAA)

Laminates; Stiffness Matrix; Structural Failure; Failure Analysis; Finite Element Method; Failure Modes

19980143217

Stability and failure of symmetrically laminated plates

Chai, Gin B., Nanyang Technological Univ., Singapore; Hoon, Kay H., Nanyang Technological Univ., Singapore; Chin, Sin S., Defence Science Organisation, Materials Research Div., Singapore; Soh, Ai K., GINTIC Inst. of Manufacturing Technology, Singapore; Structural Engineering and Mechanics; Sep. 1996; ISSN 1225-4568; Volume 4., no. 5, pp. 485-496; In English; Copyright; Avail: AIAA Dispatch

This paper describes a numerical and experimental study on the stability and failure behavior of rectangular symmetric laminated composite plates. The plates are simply supported along the unloaded edges and clamped along the loaded ends, and they are subjected to uniaxial in-plane compression. The finite element method was employed for the theoretical study. The study examines the effect of the plate's stacking sequence and aspect ratio on the stability and failure response of rectangular symmetric laminated carbon fiber reinforced plastic composite plates. The study also includes the effect of the unloaded edge support conditions on the postbuckling response and failure of the plates. Extensive experimental investigations were also carried out to supplement the finite element study. A comprehensive comparison between theory and experimental data is presented and discussed.

Author (AIAA)

Laminates; Failure Modes; Systems Stability; Buckling; Failure Analysis

19980160295

Thermally induced damage in composite space structure - Predictive methodology and experimental correlation

Park, Cecelia H., Lockheed Missiles and Space Co., Inc., USA; McManus, Hugh L., MIT, USA; 1994, pp. 161-168; In English Contract(s)/Grant(s): NAG1-1463; Copyright; Avail: Aeroplus Dispatch

A general analysis method is presented to predict matrix cracks in all plies of a composite laminate, and resulting-degraded laminate properties, as functions of temperature or thermal cycles. A shear lag solution of the stresses in the vicinity of cracks and a fracture mechanics crack formation criteria are used to predict cracks. Damage is modeled incrementally, which allows the inclusion of the effects of temperature-dependent material properties and softening of the laminate due to previous cracking. The analysis is incorporated into an easy-to-use computer program. The analysis is correlated with experimentally measured crack densities in a variety of laminates exposed to monotonically decreasing temperatures. Crack densities are measured at the edges of specimens by microscopic inspection, and throughout the specimen volumes by X-ray and sanding down of the edges. Correlation between the analytical results and the crack densities in the interiors of the specimens was quite good.

Author (AIAA)

Failure Modes; Failure Analysis; Large Space Structures; Composite Structures; Thermal Cycling Tests; Crack Propagation

19980164564

Strength, failure, and fatigue analysis of laminates

Wang, A. S. D., Drexel Univ., USA; Engineered materials handbook. Vol. 1 - Composites; 1993; 1 - Composites, pp. 236-251; In English; Copyright; Avail: Aeroplus Dispatch

Current methods of laminate failure analysis are presented for two concepts of laminate failure: one based on the individual ply failure being governed by its strength properties, and the other based on local fracture mechanisms that initiate and propagate in the laminate. Emphasis is placed on laminate failures caused by statically applied loads and by LF cyclically applied loads. Consideration is given to two general approaches that have been traditionally followed to treat fatigue failure in metals and are increasingly being applied to treat fatigue failure in composites: the point-stress failure approach and the crack propagation approach. Fatigue models based on damage accumulation are also discussed.

AIAA

Laminates; Failure Analysis; Mechanical Properties; Stress Analysis; Failure Modes; Delaminating

19980225600

Damage evolution and failure of GRP pipes under biaxial loading conditions

Golaski, L., Kielce Univ. of Technology, Poland; Ono, K., California, Univ., Los Angeles; 1998, pp. 505-510; In English; Copyright; Avail: Aeroplus Dispatch

Failure of glass-fiber-reinforced plastic laminates is investigated under biaxial loading conditions. The tests were made on tubular specimens. To vary the principal stress ratio, different loading modes were applied. On the basis of experimental results, a failure envelope correlated with loss of loading capacity of samples was developed. AE was used to observe the beginning of failure processes and trace its development during loading. These processes started when shear stress parallel to fibers or normal stress perpendicular to fiber direction was equal to its critical values. The stress level at the beginning of failure processes in laminates is compared with stress predicted on the basis of the failure criterion. The development of damage as a function of loading modes indicated by AE activity is presented.

Author (AIAA)

Damage; Failure Modes; Glass Fiber Reinforced Plastics; Pipes (Tubes); Axial Loads; Failure Analysis

20000019216

Failures at attachment holes in brittle matrix laminates

Genin, Guy M., Harvard Univ., USA; Hutchinson, John W., Harvard Univ., USA; Journal of Composite Materials; 1999; ISSN 0021-9983; Volume 33, no. 17, pp. 1600-1619; In English

Contract(s)/Grant(s): N00014-92-J-1808; Copyright; Avail: AIAA Dispatch

Mechanical attachments for a brittle-matrix fiber-reinforced cross-ply composite are analyzed. Two model problems are considered: first, a bolt loaded strut, and second, an infinitely wide plate with evenly spaced bolts. The possible failure mechanisms for the strut are identified, and the influence of bolt size, bolt location, bolt elasticity, and interfacial friction on these failure mechanisms and the associated failure loads are evaluated. The bolt spacing for the plate is identified that best takes advantage of a SiC/MAS cross-ply's ability to redistribute stresses through the mechanism of matrix cracking. Boundary value problems are solved using the FEM. The cross-ply's constitutive behavior is described by the model of Genin and Hutchinson (1977).

Author (AIAA)

Laminates; Holes (Mechanics); Failure Analysis; Failure Modes; Ceramic Matrix Composites; Bolted Joints

44

ENERGY PRODUCTION AND CONVERSION

Includes specific energy conversion systems, e.g., fuel cells; and solar, geothermal, windpower, and waterwave conversion systems; energy storage; and traditional power generators. For technologies related to nuclear energy production see 73 Nuclear Physics. For related information see also 07 Aircraft Propulsion and Power; 20 Spacecraft Propulsion and Power, and 28 Propellants and Fuels.

19800012380 General Electric Co., Space Div., Philadelphia, PA, USA

Mod 1 wind turbine generator failure modes and effects analysis

Feb 1, 1979; 95p; In English

Contract(s)/Grant(s): NAS3-20058; EX-77-A-29-1010

Report No.(s): NASA-CR-159494; DOE/NASA/0058-79/1; Avail: CASI; A05, Hardcopy; A01, Microfiche

A failure modes and effects analysis (FMEA) was directed primarily at identifying those critical failure modes that would be hazardous to life or would result in major damage to the system. Each subsystem was approached from the top down, and broken down to successive lower levels where it appeared that the criticality of the failure mode warranted more detail analysis. The results were reviewed by specialists from outside the Mod 1 program, and corrective action taken wherever recommended.

A.R.H.

Failure Modes; Hazards; Stress Analysis; System Failures; Windpowered Generators

19800018373 Argonne National Lab., Energy and Environmental Systems Div., IL, USA

Reliability and maintainability evaluation of solar control systems

Waite, E., Argonne National Lab., USA; Patterson, D., Argonne National Lab., USA; Prucha, L., Argonne National Lab., USA; Singh, H., Argonne National Lab., USA; Wolosewicz, R. M., Argonne National Lab., USA; Chopra, P. S., Argonne National Lab., USA; Mar 1, 1979; 48p; In English

Contract(s)/Grant(s): W-31-109-ENG-38

Report No.(s): SOLAR/0903-79/70; ANL/SDP/TM-79-5; Avail: CASI; A03, Hardcopy; A01, Microfiche

Control system problems affected the performance or reduced the effectiveness of 25 percent of the 47 DOE sponsored solar heating and cooling sites that were reviewed. The reliability field information presented indicates that most of the control system problems that were encountered so far were design related. The second major reason the systems experienced operating difficulties was improper sensor calibration, location, and installation. Defective components caused some operating problems, but the

incidence of these problems was approximately one-third that of the design related problems. After an introductory look at control systems and terminology, control problems are presented in detail. Since the major control problem is design-related, a Failure Modes and Effects Analysis (FMEA) on two existing systems is presented. While the FMEA cannot be used to improve the design of these operational systems, the results can be used to critique the system and to indicate where improvements can be made in future systems.

DOE

Control Equipment; Solar Cooling; Solar Heating; Temperature Sensors; Thermostats

19800056165 NASA Lewis Research Center, Cleveland, OH, USA

Modified aerospace R&QA method for wind turbines

Klein, W. E., NASA Lewis Research Center, USA; Jan 1, 1980; 5p; In English; Annual Reliability and Maintainability Symposium, January 22-24, 1980, San Francisco, CA; See also A80-40301 16-38; Avail: Issuing Activity

This paper describes the Safety, Reliability and Quality Assurance (SR&QA) approach developed for the first large wind turbine generator project, MOD-OA. The SR&QA approach to be used had to assure that the machine would not be hazardous, would operate unattended on a utility grid, would demonstrate reliable operation, and would help establish the quality assurance and maintainability requirements for wind turbine projects. The final approach consisted of a modified Failure Modes and Effects Analysis (FMEA) during the design phase, minimal hardware inspections during parts fabrication, and three documents to control activities during machine construction and operation.

AIAA

Maintainability; Quality Control; Reliability Engineering; Research and Development; Turbogenerators; Windpowered Generators

19800056167

Safety analysis of an advanced energy system facility

Lance, J. R.; Mutone, G. A., Westinghouse Electric Corp., USA; Bjoro, E. F., U.S. Department of Energy, USA; Jan 1, 1980; 7p; In English; Annual Reliability and Maintainability Symposium, January 22-24, 1980, San Francisco, CA; See also A80-40301 16-38; Copyright; Avail: Issuing Activity

This paper describes a safety analysis methodology and documentation system applied to the U.S. Department of Energy's 'first of a kind' Magnetohydrodynamic (MHD) Component Development and Integration Test Facility (CDIF). A modified Failure Mode and Effects Analysis (FMEA) is used. The CDIF FMEA approach begins with failure modes at the functional component level and analyzes the effects of propagated failure modes in interfacing systems. The results of this safety analysis have resulted in design and equipment changes, operation and maintenance requirements, and requirements for personnel exclusion areas. The safety analysis approach used is rigorous and comprehensive, but is economical in terms of effort and is particularly well suited to complex projects involving multiple contractors and organizations. The approach described herein has also been applied successfully to a later, more complex magnetohydrodynamic test facility design which is still in the concept development phase.

AIAA

Failure Analysis; Magnetohydrodynamic Generators; Safety Factors; System Failures; Test Facilities

19800056168 NASA Lewis Research Center, Cleveland, OH, USA

Photovoltaic power system reliability considerations

Lalli, V. R., NASA Lewis Research Center, USA; Jan 1, 1980; 4p; In English; Annual Reliability and Maintainability Symposium, January 22-24, 1980, San Francisco, CA; See also A80-40301 16-38; Avail: Issuing Activity

This paper describes an example of how modern engineering and safety techniques can be used to assure the reliable and safe operation of photovoltaic power systems. This particular application was for a solar cell power system demonstration project in Tangaye, Upper Volta, Africa. The techniques involve a definition of the power system natural and operating environment, use of design criteria and analysis techniques, an awareness of potential problems via the inherent reliability and FMEA methods, and use of a fail-safe and planned spare parts engineering philosophy.

AIAA

Photovoltaic Conversion; Reliability Engineering; Safety Factors; Solar Generators; Systems Engineering

19820061252 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, USA

Photovoltaic module reliability improvement through application testing and failure analysis

Dumas, L. N., Jet Propulsion Lab., California Inst. of Tech., USA; Shumka, A., California Institute of Technology, Jet Propulsion

Laboratory, Pasadena, USA; IEEE Transactions on Reliability; Aug 1, 1982; R-31, pp. Aug. 198; In English; p. 228-234. Research sponsored by the U.S. Department of Energy and NASA; Copyright; Avail: Issuing Activity

During the first four years of the U.S. Department of Energy (DOE) National Photovoltaic Program, the Jet Propulsion Laboratory Low-Cost Solar Array (LSA) Project purchased about 400 kW of photovoltaic modules for test and experiments. In order to identify, report, and analyze test and operational problems with the Block Procurement modules, a problem/failure reporting and analysis system was implemented by the LSA Project with the main purpose of providing manufacturers with feedback from test and field experience needed for the improvement of product performance and reliability. A description of the more significant types of failures is presented, taking into account interconnects, cracked cells, dielectric breakdown, delamination, and corrosion. Current design practices and reliability evaluations are also discussed. The conducted evaluation indicates that current module designs incorporate damage-resistant and fault-tolerant features which address field failure mechanisms observed to date.

AIAA

Failure Analysis; Failure Modes; Performance Tests; Photovoltaic Cells; Reliability Engineering; Solar Cells

19860003288 Midwest Energy Inst., Kansas City, MO, USA

SOLERAS: Photovoltaic power systems project. Module failure analysis *Interim Report*

Huraib, F. S., Midwest Energy Inst., USA; Imamura, M. S., Midwest Energy Inst., USA; Salim, A. A., Midwest Energy Inst., USA; Rao, N., Midwest Energy Inst., USA; Oct 1, 1984; 100p; In English; Sponsored in part by Saudi Arabian National Center for Science and Technology (SANCST)

Report No.(s): MRI/SOL-0101; Avail: CASI; A05, Hardcopy; A02, Microfiche

The SOLERAS Photovoltaic Power System (PVPS) became operational in September 1981. The system has operated satisfactorily and has experienced very little downtime. Early in 1983 some degradation in the photovoltaic (PV) field performance was detected. A series of current voltage (I-V) tests and other analyses eventually uncovered a number of PV modules that have resulted in open circuit type failure in the four cell group, or a half module. As of August 1984, the estimated number of these defective modules in the PV field was 152. In addition, there are a total of 188 defective modules in the storage warehouse, resulting in a total of 340 modules that need repairs. At the current rate of failures (seven half modules per month), an additional 112 modules would be defective by the end of January 1986, resulting in 412 defective modules. This report presents the results of the failure analysis performed during the past several months on the open circuit modules. Background information as related to the module failures and the effects of such failures on the overall PV field power output are provided. In addition, a plan to continue the monitoring of the rate of failure and analyzing the failure mechanisms is presented.

CASI

Electric Generators; Electrical Faults; Electrical Measurement; Failure Analysis; Failure Modes; Life (Durability); Photovoltaic Cells; Photovoltaic Conversion

19860013576 Argonne National Lab., IL, USA

Post-test analyses of Na/S cells and aqueous batteries

Battles, J. E., Argonne National Lab., Germany; Smaga, J. A., Argonne National Lab., Germany; Marr, J. J., Argonne National Lab., Germany; Jan 1, 1985; 3p; In English; International Battery Testing Workshop, 29 Sep. 1985, Heidelberg, Germany

Contract(s)/Grant(s): W-31-109-ENG-38

Report No.(s): DE85-018441; CONF-8509154-2; Avail: CASI; A01, Hardcopy; A01, Microfiche

Post-test examinations are conducted at Argonne National Laboratory to obtain quantitative information on electrode morphology, corrosion and degradation of the cell hardware, and mechanisms responsible for existing or future cell failures. These findings are reported to the organizations responsible for the construction of these cells and support their efforts in achieving improved cell performance, cycle life, and reliability. Results of post-test analyses of recent high-temperature sodium/sulfur cells, and of aqueous lead-acid and nickel/iron batteries are presented. In particular, the relationship between electrode performance and electrode morphology is examined for each of the three battery systems.

DOE

Failure Analysis; Failure Modes; Lead Acid Batteries; Nickel Iron Batteries; Performance Tests; Sodium Sulfur Batteries

19900011159 Hughes Aircraft Co., Los Angeles, CA, USA

KOH concentration effect on the cycle life of nickel-hydrogen cells. Part 4: Results of failure analyses

Lim, H. S., Hughes Aircraft Co., USA; Verzwylt, S. A., Hughes Aircraft Co., USA; NASA, Lewis Research Center, Space Electrochemical Research and Technology (SERT), 1989; Dec 1, 1989, pp. p 243-25; In English; Avail: CASI; A03, Hardcopy; A03, Microfiche

KOH concentration effects on cycle life of a Ni/H₂ cell have been studied by carrying out a cycle life test of ten Ni/H₂ boiler plate cells which contain electrolytes of various KOH concentrations. Failure analyses of these cells were carried out after completion of the life test which accumulated up to 40,000 cycles at an 80 percent depth of discharge over a period of 3.7 years. These failure analyses included studies on changes of electrical characteristics of test cells and component analyses after disassembly of the cell. The component analyses included visual inspections, dimensional changes, capacity measurements of nickel electrodes, scanning electron microscopy, BET surface area measurements, and chemical analyses. Results have indicated that failure mode and change in the nickel electrode varied as the concentration was varied, especially, when the concentration was changed from 31 percent or higher to 26 percent or lower.

CASI

Concentration (Composition); Electrochemical Cells; Electrodes; Electrolytes; Failure Analysis; Failure Modes; Life (Durability); Nickel; Potassium Hydroxides

19960009309 MATRA Marconi Space, Toulouse, France

Investigation of new short circuit modes on solar arrays

Soubeyran, A., MATRA Marconi Space, France; Matucci, A., Proel Technologie, Italy; Levy, L., Centre d'Etudes et de Recherches, France; Mandeville, J. C., Centre d'Etudes et de Recherches, France; Gerlach, L., European Space Agency. European Space Research and Technology Center, Netherlands; Stevens, J., TRW, Inc., USA; ESA, Proceedings of 4th European Space Power Conference (ESPC). Volume 2: Photovoltaic Generators, Energy Storage; Sep 1, 1995, pp. p 567-571; In English; See also N96-16434 04-20; Sponsored by ESA; Copyright; Avail: CASI; A01, Hardcopy; A03, Microfiche

Spacecraft containing rigid honeycomb structures and an insulating layer of 25 micron thick Kapton (trademark) and with a nominal bus voltage of greater than 40 V, often experienced short circuit failures while in space. In relation to this problem, new ways of understanding Kapton (trademark), from theoretical and experimental viewpoints, were investigated. The following aspects were considered: discharge triggered by micrometeoroid impact; Kapton (trademark) aging by internal partial discharges; degradation due to discharge coupling with dynamic electrical system interaction involving long line inductance, and degradation due to high electrical stress in the Kapton (trademark) layer. Results from the experimental study justify many conceptual ideas. New processes were discovered involving interconnection damage when submitted to high biasing, and surface short circuiting with material burning and charring.

Author (ESA)

Failure Analysis; Failure Modes; Short Circuits; Solar Arrays; Spacecraft Power Supplies

46 GEOPHYSICS

Includes earth structure and dynamics, aeronomy; upper and lower atmosphere studies; ionospheric and magnetospheric physics; and geomagnetism. For related information see 47 Meteorology and Climatology; and 93 Space Radiation.

19810010060 Rensselaer Polytechnic Inst., Troy, NY, USA

Reliability of geotechnical systems *Topical*

Harrop-Williams, K. O., Rensselaer Polytechnic Inst., USA; Jan 1, 1980; 281p; In English; Avail: Univ. Microfilms Order No. 8103766, Unavail. Microfiche

The main objectives are: to examine the interdependence of the failure modes of some common geotechnical structures (i.e., soil slopes, earth retaining structures and shallow foundations); to provide a probabilistic description to the problem of interference of two near by sited structures; and to assess the reliability of one or more geotechnical structures having inter-dependent modes of failure. The above objectives were achieved within the framework of probability theory and reliability analysis. The measure of safety that was employed throughout the study was the probability of failure defined as the probability with which the resistance (R) of structure along a given mode of failure is exceeded by the applied loading (S). The effect of the correlation of R and S on the probability of failure was investigated. Soil strength parameters c and phi were introduced as correlated random variables and a probabilistic model was developed for the description of their joint distribution.

Dissert Abstr.

Failure Analysis; Failure Modes; Reliability; Soil Mechanics; Structural Stability

60

COMPUTER OPERATIONS AND HARDWARE

Includes hardware for computer graphics, firmware and data processing. For components see 33 Electronics and Electrical Engineering. For computer vision see 63 Cybernetics, Artificial Intelligence and Robotics.

19710061407

Bias - A network analysis computer program useful to the reliability engineer

Magnuson, W. G., Jr.; Willows, J. L., Jr.; Aug 1, 1971, pp. 104-111. (; In English; See also Transactions On Reliability;; Aec-Sponsored Research.; Copyright; Avail: Issuing Activity

Bias network analysis computer program for reliability analysis suited to failure mode, criticality, drift and catastrophic failures prediction

AIAA

Computer Aided Design; Computer Programs; Failure Analysis; Failure Modes; Network Analysis; Reliability Analysis

19890030635

Strategies for testing electro-optic devices

Brown, Philip S., Harris Corp., USA; Jan 1, 1988; 5p; In English; AUTOTESTCON '88 - IEEE International Automatic Testing Conference, Oct. 4-6, 1988, Minneapolis, MN, USA; See also A89-17998 05-59; Copyright; Avail: Issuing Activity

A fully automatic modular ATLAS/CHIL-driven E/O (electrooptic) demonstrator is described. The system utilizes collimation and sampling techniques to automate testing which is currently performed manually. The resultant system is capable of testing existing units under test (UTs) in a fraction of the time currently required. The system was used to test the F-18 E/O Pod.

AIAA

Automatic Test Equipment; Failure Analysis; Failure Modes; Infrared Imagery; Laser Applications; Optoelectronic Devices

61

COMPUTER PROGRAMMING AND SOFTWARE

Includes software engineering, computer programs, routines, algorithms, and specific applications, e.g., CAD/CAM. For computer software applied to specific applications, see also the associated category.

19790067206

Software failure modes and effects analysis

Reifer, D. J., Software Management Consultants, USA; IEEE Transactions on Reliability; Aug 1, 1979; R-28, pp. Aug. 197; In English; p. 247-249; Copyright; Avail: Issuing Activity

This concept paper discusses the possible use of failure modes and effects analysis (FMEA) as a means to produce more reliable software. FMEA is a fault avoidance technique whose objective is to identify hazards in requirements that have the potential to either endanger mission success or significantly impact life-cycle costs. FMEA techniques can be profitably applied during the analysis stage to identify potential hazards in requirements and design. As hazards are identified, software defenses can be developed using fault tolerant or self-checking techniques to reduce the probability of their occurrence once the program is implemented. Critical design features can also be demonstrated a priori analytically using proof of correctness techniques prior to their implementation if warranted by cost and criticality.

AIAA

Computer Programs; Fail-Safe Systems; Failure Modes; Life Cycle Costs; Reliability Engineering

19800056158

Hardware and software - An analytical approach

Bunce, W. L., Boeing Aerospace Co., USA; Jan 1, 1980; 5p; In English; Annual Reliability and Maintainability Symposium, January 22-24, 1980, San Francisco, CA; See also A80-40301 16-38; Copyright; Avail: Issuing Activity

An approach to analyzing the interaction of hardware failure modes with computer software is described. The approach considers the software requirements, not the design or implementation and is an extension of the FMEA (failure mode and effects

analysis) discipline. It has been developed to address the needs of the Space Shuttle Orbiter Project and is being applied to Orbiter subsystems. The basic approach is applicable to other hardware/software systems, and guidelines for its application are presented.
AIAA
Airborne/Spaceborne Computers; Computer Programs; Computer Systems Design; Failure Modes; Hardware; Space Shuttle Orbiters

19820016510 TRW, Inc., Space and Technology Group., Redondo Beach, CA, USA

Software product assurance: Learning lessons from hardware

Sloane, E., TRW, Inc., USA; Wroblewski, J., TRW, Inc., USA; ESA 2nd ESA Prod. Assurance Symp.; Jan 1, 1982, pp. p 191-200; In English; See also N82-24362 15-31; Avail: CASI; A02, Hardcopy; A01, Microfiche

The application of failure mode and effects analysis (FMEA) and critical item control to software is discussed. System FMEA for a satellite computer is shown. It emphasizes software functions, e.g., attitude control, and the effects of software failure on hardware performance. Unit interface FMEA is achieved by analyzing logic flow between routines in a program or between programs. Software errors are hypothesized and failure effects followed through in order to determine effects on hardware and software. Piece part FMEA is limited to elements whose failure causes immediate loss of the mission. Critical item plans can be generated for mission critical software and software deemed risky because of unusual procedures of difficulty in meeting specifications. Variables can be tested at or over limits. Critical timing threads can be stress tested to the maximum. Error checking and redundant software can be used.

CASI

Computer Programming; Computer Systems Programs; Failure Analysis; Program Verification (Computers); Quality Control

19840003710 Rome Air Development Center, Griffiss AFB, NY, USA

The evolution and practical applications of failure modes and effects analyses

Dussault, H. B., Rome Air Development Center, USA; Mar 1, 1983; 114p; In English

Contract(s)/Grant(s): AF PROJ. 2338

Report No.(s): AD-A131358; RADC-TR-83-72; Avail: CASI; A06, Hardcopy; A02, Microfiche

Failure effects analysis allows a product to be studied early in its design and development stages where undesirable failure effects can be identified and readily corrected. This report is intended to give the reader a broad, general background in techniques available for failure effects analysis and their usefulness. Sixteen separate techniques, ranging from tabular failure modes and effects analysis and fault tree analysis to lesser known and more recently introduced techniques such as hardware/software interface analysis, are discussed. The current status and prospects for the future failure effects analysis are also discussed in the report.

DTIC

Failure; Failure Analysis; Failure Modes

19860001368 Los Alamos Scientific Lab., NM, USA

New probabilistic modeling and simulation methods for complex time-dependent systems

Bartholomew, R. J., Los Alamos Scientific Lab., USA; Jan 1, 1985; 13p; In English; 7th; Intern. System Safety Conf., 25 Jul. 1985, San Jose, CA, USA

Contract(s)/Grant(s): W-7405-ENG-36

Report No.(s): DE85-009575; LA-UR-85-828; CONF-850723-2; Avail: CASI; A03, Hardcopy; A01, Microfiche

This paper is a tutorial that presents a new method of modeling the probabilistic description of failure mechanisms in complex, time-dependent systems. The method of modeling employs a state vector differential equation representation of cumulative failure probabilities derived from Markov models associated with certain generic fault trees, and the method automatically includes common cause/common mode statistical dependences, as well as time-related dependencies not considered in the literature previously. Simulations of these models employ a population dynamics representation of a probability space involving probability particle transitions among the Markov disjoint states. The particle transitions are governed by a random, Monte Carlo selection process.

DOE

Computation; Computerized Simulation; Failure Analysis; Failure Modes; Fault Trees; Markov Processes; Monte Carlo Method; Probability Theory; Time Dependence

19860013863 California Univ., Berkeley. Lawrence Berkeley Lab, CA, USA

Outline of a failure: A true story of nine precepts, with two morals

Stevens, D. F., California Univ., Ireland; Aug 1, 1985; 7p; In English; 10th; World Computer Congress, 1 Sep. 1986, Dublin
Contract(s)/Grant(s): DE-AC03-76SF-00098

Report No.(s): DE86-000601; LBL-20084; CONF-860924-1; Avail: CASI; A02, Hardcopy; A01, Microfiche

This is not a conventional case history. It is concerned with failure rather than with triumph, and further, with a personal definition of failure. Failure, like beauty, is in the eye of the beholder. The system I shall call SOS, when measured in terms of absolute achievement, might not be considered a failure. When measured against corporate plans and goals it might not be admitted to be a failure. But when measured against some aspects of the state-of-the-art it professed to advance, against fundamental ergonomic principles, and, especially, against its potential, it was a failure. Specifically, it failed to meet the expectations of one user. It is only fair, then, to begin by characterizing those expectations and giving some indication of their sources. Then follow five sections on various classes of failure. (The Precepts of the title are embedded in these sections.) The paper concludes with a brief discussion of the Two Morals.

DOE

Computer Programs; Failure Analysis; Failure Modes

19880042387

Practical RAMCAD

Jackson, Tyrone, TRW, Inc., USA; Jan 1, 1987; 7p; In English; 33rd; Institute of Environmental Sciences, Annual Technical Meeting, May 5-7, 1987, San Jose, CA, USA; Sponsored by Institute of Environmental Sciences; See also A88-29601; Copyright; Avail: Issuing Activity

In order to accomplish the timely completion of design support analyses, an effort has been made to combine computer-aided reliability and maintainability (RAM) techniques with CAD software. The resulting RAMCAD systems can access and analyze electronically stored design data. Attention is presently given to the use of a prototype RAMCAD system to accomplish a failure modes-and-effects analysis (FMEA). The FMEA concerns the Mercury-Redstone rocket test launch of November 21, 1961, which suffered a premature engine shutoff.

AIAA

Computer Aided Design; Maintainability; Reliability Analysis

19900041354

Reliability analysis of large software systems - Defect data modeling

Levendel, Ytzhak, AT&T Bell Laboratories, USA; IEEE Transactions on Software Engineering; Feb 1, 1990; ISSN 0098-5589; 16, pp. 141-152; In English; Copyright; Avail: Issuing Activity

The author analyzes and models the software development process, and presents field experience for large distributed systems. Defect removal is shown to be the bottleneck in achieving the appropriate quality level before system deployment in the field. The time to defect detection, the defect repair time and a factor reflecting the introduction of new defects due to imperfect defect repair are some of the 'constants' in the laws governing defect removal. Test coverage is a measure of defect-removal effectiveness. A birth-death mathematical model based on these constants is developed and used to model field failure report data. The birth-death model is contrasted with a more classical decreasing exponential model. Both models indicate that defect removal is not a cost-effective way to achieve quality. As a result of the long latency of software defects in a system, defect prevention is suggested to be a far more practical solution to quality than defect removal.

AIAA

Applications Programs (Computers); Component Reliability; Computer Program Integrity; Distributed Processing; Failure Analysis; Failure Modes

19910013439 Cornell Univ., Dept. of Computer Science., Ithaca, NY, USA

Masking failures of multidimensional sensors (extended abstract)

Chew, Paul, Cornell Univ., USA; Marzullo, Keith, Cornell Univ., USA; Dec 6, 1990; 11p; In English
Contract(s)/Grant(s): N00014-88-K-0591; N00014-89-J-1946; N00140-87-C-8904; NSF IRI-90-06137; NAG2-593
Report No.(s): NASA-CR-188120; NAS 1.26:188120; Avail: CASI; A03, Hardcopy; A01, Microfiche

When a computer monitors a physical process, the computer uses sensors to determine the values of the physical variables that represent the state of the process. A sensor can sometimes fail, however, and in the worst case report a value completely unrelated to the true physical value. The work described is motivated by a methodology for transforming a process control program that can not tolerate sensor failure into one that can. In this methodology, a reliable abstract sensor is created by combining

information from several real sensors that measure the same physical value. to be useful, an abstract sensor must deliver reasonably accurate information at reasonable computational cost. Sensors are considered that deliver multidimensional values (e.g., location or velocity in three dimensions, or both temperature and pressure). Geometric techniques are used to derive upper bounds on abstract sensor accuracy and to develop efficient algorithms for implementing abstract sensors.

GRA

Algorithms; Computers; Failure Analysis; Failure Modes; Fault Tolerance; Masking; Monitors

19910068387

Next generation TPS architecture

Poon, Andrew; Bertch, William J.; Wood, Jay B., General Dynamics Corp., USA; Jan 1, 1990; 11p; In English; AUTOTESTCON '90; IEEE Systems Readiness Technology Conference, Sept. 17-20, 1990, San Antonio, TX, USA; Sponsored by IEEE; See also A91-53001; Copyright; Avail: Issuing Activity

The authors describe the symptom-model-based (SMB) approach, which correlates the failure symptom with the ambiguity group using historical data and diagnostic knowledge of the specific line replaceable units (LRUs). The SMB approach incorporates three key techniques for developing a next-generation TPS (test program set) architecture. The first technique is model-based diagnosis, which involves isolating the cause of failure based on the defined structure and functions of the components. Several different techniques and levels of detail for modeling an LRU are considered. The second technique is empirical diagnosis, which involves computing the most probable cause of failure using historical data and results from failure modes and effects analysis (FMEA). The third technique is rule-based diagnosis, which uses the knowledge of experts to isolate failures in an expedient manner. The implementation of each of these techniques is evaluated based on the capability to fault isolate to the correct component, the time to fault isolate, and the complexity of the associated TPS structure.

AIAA

Artificial Intelligence; Diagnosis; Failure Analysis; Failure Modes; Self Tests

19910068390

Dynamic sequencing of test programs

Levy, Arthur; Pizzariella, John, Harris Corp., USA; Jan 1, 1990; 5p; In English; AUTOTESTCON '90; IEEE Systems Readiness Technology Conference, Sept. 17-20, 1990, San Antonio, TX, USA; Sponsored by IEEE; See also A91-53001; Copyright; Avail: Issuing Activity

A novel ATE (automatic test equipment) test program development/execution concept is being employed at Harris. Test program sets are constructed as a collection of atomic tests (i.e., independent, totally encapsulated tests) whose sequence is determined by a test manager with adaptive reasoning. The tests can be independently constructed and compiled, allowing for more parallel development and reduced maintenance costs. Communication between tests is achieved through a common data storage, and the setup conditions are reconciled by a single setup test module whose actions are directed by a state vector. The test manager employs experiential data to adjust relative failure probabilities in optimally sequencing the atomic tests.

AIAA

Automatic Test Equipment; Expert Systems; Failure Analysis; Failure Modes; Self Tests

19920009832 Naval Postgraduate School, Dept. of Computer Science., Monterey, CA, USA

Analytical derivation of software failure regions *Topical Progress Report, Oct. 1990 - Sep. 1991*

Shileall, Timothy J., Naval Postgraduate School, USA; Bolchoz, John M., Naval Postgraduate School, USA; Griffin, Rachel, Naval Postgraduate School, USA; Sep 9, 1991; 34p; In English

Report No.(s): AD-A244021; NPS-CS-91-003; Avail: CASI; A03, Hardcopy; A01, Microfiche

This paper proposes an analytical method for deriving software failure regions, which are regions of the input space that are mapped to failures by specific faults. Previous studies have used empirical rather than analytical approaches to derive failure regions. A manual technique is presented and proven to produce the necessary and sufficient conditions of a fault being executed and leading to a failure. Semiautomated tools to assist in the manual technique are discussed, as is the use of failure regions in regression testing.

DTIC

Computer Programs; Failure Analysis; Failure Modes

19950019625 Finnish Centre for Radiation and Nuclear Safety, Helsinki, Finland

Reliability analysis of software based safety functions

Pulkkinen, U., Technical Research Centre of Finland, Finland; May 1, 1993; 65p; In English

Report No.(s): DE95-606516; STUK-YTO-TR-53; Avail: CASI; A04, Hardcopy; A01, Microfiche

The methods applicable in the reliability analysis of software based safety functions are described in the report. Although the safety functions also include other components, the main emphasis in the report is on the reliability analysis of software. The check list type qualitative reliability analysis methods, such as failure mode and effects analysis (FMEA), are described, as well as the software fault tree analysis. The safety analysis based on the Petri nets is discussed. The most essential concepts and models of quantitative software reliability analysis are described. The most common software metrics and their combined use with software reliability models are discussed. The application of software reliability models in PSA is evaluated; it is observed that the recent software reliability models do not produce the estimates needed in PSA directly. As a result from the study some recommendations and conclusions are drawn. The need of formal methods in the analysis and development of software based systems, the applicability of qualitative reliability engineering methods in connection to PSA and the need to make more precise the requirements for software based systems and their analyses in the regulatory guides should be mentioned.

DOE

Checkout; Computer Programs; Failure Analysis; Failure Modes; Fault Trees; Petri Nets; Qualitative Analysis; Quantitative Analysis; Reliability Analysis; Reliability Engineering; Software Reliability

19960055176 California Univ., Dept. of Computer Science, Davis, CA USA

A Computer Model of Text Comprehension and Question Answering for Failure Analysis

Alvarado, Sergio J., California Univ., USA; Braun, Ronald K., California Univ., USA; Mock, Kenrick J., California Univ., USA; [1993]; 342p; In English

Contract(s)/Grant(s): NCA2-721

Report No.(s): NASA-CR-202461; NAS 1.26: 202461; CSE-93-4; No Copyright; Avail: CASI; A15, Hardcopy; A03, Microfiche

The research described in this technical report is aimed at extending previous theories of natural language processing and memory search and retrieval. In particular, this research has been concerned with the development of a model of text comprehension and question answering that uses case-based reasoning techniques to acquire knowledge of failure analysis from input text, and answer questions regarding diagnosis and repair of failures in complex systems, such as NASA's Space Station Freedom. The major goal has been to develop a process model that accounts for (a) how to build a knowledge base of system failures and repair procedures from textual descriptions that appear in NASA's FMEA (Failure Modes and Effects Analysis) manuals, and (b) how to use that knowledge base to evaluate causes and effects of failures, and provide diagnosis and repair procedures. This process model has been implemented in an experimental computer program called FANSYS (Failure ANALYSIS SYStem), which is a text comprehension and question answering system for the analysis of failures occurring within the data management system (DMS) of NASA's Space Station Freedom. This project received funds from NASA Ames Research Center to support three major tasks in a period of a year: (1) analysis of conceptual content of system-failure manuals; (2) characterization of the knowledge structures and processes underlying the computational analysis of failures; and (3) implementation of an experimental version of FANSYS that reads a few segments of the manuals, and answers a number of questions involving failure diagnosis and repair.

Author

Failure Analysis; Computerized Simulation; Artificial Intelligence; Natural Language Processing

19970014942 Aerojet-General Corp., Azusa, CA USA

Meteorological Satellites (METSAT) and Earth Observing System (EOS) Advanced Microwave Sounding Unit-A (AMSU-A) Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL)

Mar. 1996; 112p; In English

Contract(s)/Grant(s): NAS5-32314

Report No.(s): NASA-CR-203657; NAS 1.26:203657; AEROJET-10378A; CDRL-108; CDRL-507; No Copyright; Avail: CASI; A06, Hardcopy; A02, Microfiche

This Failure Modes and Effects Analysis (FMEA) is for the Advanced Microwave Sounding Unit-A (AMSU-A) instruments that are being designed and manufactured for the Meteorological Satellites Project (METSAT) and the Earth Observing System (EOS) integrated programs. The FMEA analyzes the design of the METSAT and EOS instruments as they currently exist. This FMEA is intended to identify METSAT and EOS failure modes and their effect on spacecraft-instrument and

instrument-component interfaces. The prime objective of this FMEA is to identify potential catastrophic and critical failures so that susceptibility to the failures and their effects can be eliminated from the METSAT/EOS instruments.

Author

Earth Observing System (EOS); Meteorological Satellites; Failure Analysis

19980027502

Using failure modes and effects simulation as a means of reliability analysis

Palumbo, Daniel L., NASA Langley Research Center, USA; 1992, pp. 102-107; In English; Copyright; Avail: Aeroplus Dispatch

Failure mode and effects analysis (FMEA) creates a knowledge base of system response to component failure. Reliability analysis draws on the FMEA in combination with component failure rates and system recovery rates to construct a reliability model that can be solved for the system probability of failure. This paper introduces Failure Modes and Effects Simulation (FMES) as an effective way to do both FMEA and reliability analysis. Using FMES, a system is described as a connected set of components. A component is defined by its interconnects, its state, and its behavioral description. Behavioral descriptions characterize how changes occur in the component and its output states. The FMES technique has been evaluated in a tool called the Reliability Estimation Testbed (REST). A Reliability Modeling Language (RML) was developed as part of REST to support FMES. REST and RML have been used to analyze a system consisting of a quad computer connected to two reconfiguring mesh networks and several quad redundant devices, a system totaling 100 components.

Author (AIAA)

Failure Modes; Reliability Analysis; Knowledge Bases (Artificial Intelligence); Computerized Simulation

19980067721

Automated computer aided diagnosis and simulation

Abou-Khalil, Ali, NASA Ames Research Center, USA; Boyd, Mark A., NASA Ames Research Center, USA; 1997, pp. 4.5-21 to 4.5-28; In English; Copyright; Avail: Aeroplus Dispatch

This paper gives an overview of an approach to building computer-aided diagnosis systems, and demonstrates the importance of computer simulation in the development of such systems. Attention is given to the illustrative case of the Stratospheric Observatory For Infrared Astronomy, whose Secondary Mirror Assembly subsystem incorporates an Advanced Diagnostic System.

Author (AIAA)

Computerized Simulation; Aerospace Engineering; Spacecraft Design; Sofia (Airborne Observatory); Failure Analysis; Failure Modes

19980087711

Quantitative FMEA automation

Montgomery, Thomas A., Ford Motor Co., USA; Marko, Kenneth A., Ford Motor Co., USA; 1997, pp. 226-228; In English; Copyright; Avail: AIAA Dispatch

By providing a structured approach for considering potential failures and their effects, Failure Mode and Effects Analysis (FMEA) is an important process applied to the development of reliable and maintainable products. FMEA reports are used by design, test and diagnostic engineers, impacting products throughout their life cycle. FMEA automation promises to streamline the traditional (brainstorming) approach to performing an FMEA by aiding the FMEA reasoning process, helping to produce a report that is more timely, complete and consistent. Most of the published approaches to automating FMEA rely on qualitative simulators and produce a report that is most relevant early in the design cycle. The software described here uses a quantitative simulator, producing results that are not only more accurate for designers, but are also more useful to test and diagnostics engineers. The result is a contribution to concurrent engineering efforts in the design, manufacture, and support of analog electronics that is not possible with tools based on qualitative simulators.

Author (AIAA)

System Failures; Failure Modes; Automation; Reliability Analysis; Life Cycle Costs

19980104552

Fault mode analysis based on compositional modeling

Winston, Howard, United Technologies Research Center, USA; Tulpule, Sharayu, United Technologies Research Center, USA; Jun. 1997; In English

Report No.(s): ASME Paper 97-GT-034; Copyright; Avail: AIAA Dispatch

A framework for simulating failure modes in gas turbine engines has been implemented based on prior work on compositional modeling. We believe this design methodology and simulation architecture can enable scaleable and robust simulations of the precursors, manifestations, and consequences of failure modes in complex engineered devices. An object-oriented modeling language was implemented to represent devices in terms of primitive and recursively defined compound components. Primitive components can encapsulate equations that always apply to their descriptions. The modeling language also includes objects that represent physical processes (i.e., composable model fragments) that encapsulate equations that apply when the fragments' applicability and activation conditions are satisfied. Model fragments may also contain terms that can contribute to the value of component parameters when those fragments are activated. To interleave model-building and simulation, equation models are implemented as constraint networks. This precludes the need to determine explicit solution orders for sets of equations and facilitates the incremental modification of equation models. As a failure scenario unfolds, the simulation can be interrupted, a new set of model fragments can be composed into the constraint network, and the simulation continued. This failure simulation framework is illustrated with a simple multistage gas turbine failure scenario.

Author (AIAA)

Failure Analysis; Failure Modes; Gas Turbine Engines; Control Systems Design

19980124144

On software reliability and code coverage

Karcich, Richard M., Storage Technology Corp., USA; Skibbe, Robert, Storage Technology Corp., USA; Mathur, Aditya P., Purdue Univ., USA; Garg, Praerit, Purdue Univ., USA; 1996, pp. 297-308; In English; Copyright; Avail: Aeroplus Dispatch

Failure and module coverage data were collected during the system testing phase of a commercial hardware-software system called Product S. The Goel-Okumoto and Musa-Okumoto models were used to predict the Mean Test Cases to Failure (MTCTF) for these data. It was observed that the errors in predictions of MTCTF correlate with a sharp rise in code coverage. The sharp rise occurs when testers test code which was not previously tested. This observation suggests that software reliability prediction models may be able to improve the accuracy of prediction by accounting for code coverage.

Author (AIAA)

Software Reliability; Mtb; Failure Analysis; Codes; Failure Modes; Error Analysis

19980191270

Aircraft electrical load analysis program (AELAP)

Clarke, James J., Grumman Corp., USA; Wertheim, Max M.; 1993, pp. 1.7-1.12; In English; Copyright; Avail: Aeroplus Dispatch

Consideration is given to the AELAP (Aircraft Electrical Load Analysis Program), designed to satisfy the requirements of MIL-E-7016F (the military specification governing content and format of load analyses) to compute and report on bus and source loading for each prescribed operating condition of a military aircraft. AELAP tool characteristics are presented, with emphasis on input data and program output. It is shown that AELAP surpasses the requirements of MIL-E-7016F by a large margin. The program is used by both contractor and customer to verify adequacy of the aircraft electrical system and design. It is also used for design and sizing purposes, study of emergency conditions, troubleshooting, 'what if' analyses, and as an FMEA tool.

AIAA

Aircraft Equipment; Avionics; Computer Programs

19990037820

Application of VHDL in test program development

Sacher, Eric, Serendipity Systems, Inc., USA; 1998, pp. 14-21; In English; Copyright; Avail: AIAA Dispatch

This paper describes a test programming paradigm based on VHSIC Hardware Description Language (VHDL) and its application in a HDL-based simulation tool set. The modeling of the unit under test, the writing of a test bench code, the simulation run, and fault isolation are discussed.

AIAA

High Level Languages; Failure Modes; Software Development Tools; Failure Analysis

19990056042

A modified FMEA tool for use in identifying and addressing common cause failure risks in industry

Childs, Joseph A., Texas Instruments, Inc., Dallas, USA; Mosleh, Ali, Maryland, Univ., College Park; 1999, pp. 19-24; In English; Copyright; Avail: AIAA Dispatch

The nature of common cause failures (CCFs) is explored in the context of existing analytical techniques. Failure Modes and Effects Analysis (FMEA) is described as a means for accomplishing early risk assessment in the context of an existing analysis

framework. Cause and coupling factor taxonomies are refined to fit the FMEA methodology. This modification allows consideration of CCF risks. Blending this methodology with the standard FMEA process enables a seamless prioritization of single failure and CCF risks for further studies and actions. An example is provided to illustrate the use of this new tool.

Author (AIAA)

Failure Analysis; Failure Modes; Computer Techniques; Industries

19990056043

FMECA modeling - A new approach

Bot, Yizhak, BQR Reliability Engineering, Ltd., Israel; 1999, pp. 25-28; In English; Copyright; Avail: AIAA Dispatch

We introduce a major enhancement to the Failure Mode Effects and Criticality Analysis (FMECA) to provide a more accurate, simpler, more accessible, and more frequently used computerized analysis tool. We introduce new terminology to enhance the well-known standards, while assuring their full support. FMECA is used to analyze the effects of system assembly failure modes on the overall system functionality (end effects). The FMECA results serve as the main input to define built in tests (BIT) that can automatically detect and isolate system failures as they occur and act as required to increase system availability. FMECA also serves as a dictionary of failure modes for safety and logistics analysis. In this article we present a new approach to the FMECA algorithm. The basis for this approach is two-fold: (1) Introducing new FMECA terms: 'Good Modes' and 'Next Brother Effects', and (2) binding together the system Reliability Block Diagram (RBD) and the FMECA analysis. In order to do so, we use an innovative algorithm for virtual dynamic functional trees. This computerized algorithm automatically constructs a separate functional tree for each failure mode. These terms lead to a much more flexible computerized failure modes analysis tool mechanism and, most importantly, to BIT definitions enhancement, which increases systems reliability, safety, and supportability and shortens maintenance times.

Author (AIAA)

Failure Analysis; Computer Techniques; Failure Modes; Safety Factors; Block Diagrams

63

CYBERNETICS, ARTIFICIAL INTELLIGENCE AND ROBOTICS

Includes feedback and control theory, information theory, machine learning, and expert systems. For related information see also 54 Man/System Technology and Life Support.

19830043578

Mode-fault diagnosis and a design of testability

Huang, Z. F.; Lin, C.; Liu, R., Notre Dame, University, USA; Jan 1, 1981; 6p; In English; 20th; In: Conference on Decision and Control, 20th, and Symposium on Adaptive Processes, December 16-18, 1981, San Diego, CA; Sponsored by Navy; See also A83-24701 09-63

Contract(s)/Grant(s): N00014-78-C-0444; Copyright; Avail: Issuing Activity

A concept of k-node-fault testability is introduced. A sufficient and almost necessary condition for testability as well as the test procedure is presented. This condition requires little computation with a few test points in view of the complexity of the problem of multi-fault diagnosis of large-scale circuits. This condition is further evolved to a necessary and almost sufficient condition for testability. A unique feature of this condition is that it depends only on the graph of the circuit, not on the element values. Based on this condition, a design of testability is established.

AIAA

Analog Circuits; Circuit Reliability; Electronic Equipment Tests; Failure Analysis; Failure Modes; Network Analysis

19840042735

The controversy over use of SPRT and GLR techniques and other loose-ends in failure detection

Kerr, T. H., Intermetrics, Inc., USA; Jan 1, 1983; 12p; In English; See also A84-25451 10-63; Copyright; Avail: Issuing Activity

Results and criticisms of the use of Sequential Probability Ratio Tests (SPRT) and Generalized Likelihood Ratio (GLR) are discussed and a perspective on the current status of SPRT and GLR for failure and event detection is provided. An overview of unresolved issues in SPRT, GLR, and other failure detection techniques is given. New results for one such approach, the two-confidence region approach, are presented.

AIAA

Failure Analysis; Failure Modes; Maximum Likelihood Estimates; Sequential Analysis; System Failures

19850065643 Alphatech, Inc., Burlington, MA, USA

A design methodology for robust failure detection and isolation

Pattipati, K. R., Alphatech, Inc., USA; Willsky, A. S., Alphatech, Inc., USA; Deckert, J. C., Alphatech, Inc., USA; Eterno, J. S., Alphatech, Inc., USA; Weiss, J. S., Alphatech, Inc., USA; Jan 1, 1984; 8p; In English; 1984 American Control Conference, June 6-8, 1984, San Diego, CA; See also A85-47676 23-63

Contract(s)/Grant(s): NAS3-24078; Copyright; Avail: Issuing Activity

A decentralized failure detection and isolation (FDI) methodology, which is robust with respect to model uncertainties and noise, is presented. Redundancy metrics are developed, and optimization problems are posed for the choices of robust parity relations. Closed-form solutions for some special failure cases are given. Connections are drawn with other disciplines, and the use of the metrics to evaluate alternative FDI schemes is discussed.

AIAA

Failure Analysis; Failure Modes; Kalman Filters; Robustness (Mathematics); Stochastic Processes

19880019986 Boeing Computer Support Services, Inc., Huntsville, AL, USA

Failure modes and effects analysis automation

Kamhieh, Cynthia H., Boeing Computer Services Co., USA; Cutts, Dannie E., Boeing Computer Services Co., USA; Purves, R. Byron, Boeing Aerospace Co., USA; NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications; Aug 1, 1988, pp. p 169-176; In English; See also N88-29351 23-61; Avail: CASI; A02, Hardcopy; A06, Microfiche

A failure modes and effects analysis (FMEA) assistant was implemented as a knowledge based system and will be used during design of the Space Station to aid engineers in performing the complex task of tracking failures throughout the entire design effort. The three major directions in which automation was pursued were the clerical components of the FMEA process, the knowledge acquisition aspects of FMEA, and the failure propagation/analysis portions of the FMEA task. The system is accessible to design, safety, and reliability engineers at single user workstations and, although not designed to replace conventional FMEA, it is expected to decrease by many man years the time required to perform the analysis.

CASI

Automatic Control; Computer Techniques; Data Bases; Failure Analysis; Failure Modes

19890035076

Survey of model-based failure detection and isolation in complex plants

Gertler, Janos J., George Mason University, USA; IEEE Control Systems Magazine; Dec 1, 1988; ISSN 0272-1708; 8, pp. 3-11; In English; Copyright; Avail: Issuing Activity

Techniques to detect and isolate failures in complex technological systems, such as sensor biases, actuator malfunctions, leaks, and equipment deterioration are surveyed. The methods are based on analytical redundancy afforded by a mathematical model of the system. The main components of such techniques are residual generation using the model, signature generation by statistical testing, and signature analysis. Model-structural conditions for failure isolation are introduced together with transformation methods to implement them. Sensitivity and robustness considerations are presented, and a design framework based on model redundancy is proposed.

AIAA

Complex Systems; Decision Making; Failure Analysis; Failure Modes; Statistical Tests

19910013465 Mitre Corp., Houston, TX, USA

A failure recovery planning prototype for Space Station Freedom

Hammen, David G., Mitre Corp., USA; Kelly, Christine M., Mitre Corp., USA; NASA, Goddard Space Flight Center, The 1991 Goddard Conference on Space Applications of Artificial Intelligence; May 1, 1991, pp. p 113-127; In English; See also N91-22769 14-63

Contract(s)/Grant(s): NAS9-18057; Avail: CASI; A03, Hardcopy; A03, Microfiche

NASA is investigating the use of advanced automation to enhance crew productivity for Space Station Freedom in numerous areas, including failure management. A prototype is described that uses various advanced automation techniques to generate courses of action whose intents are to recover from a diagnosed failure, and to do so within the constraints levied by the failure and by Freedom's configuration and operating conditions.

CASI

Artificial Intelligence; Failure Analysis; Failure Modes; Management Methods; Planning; Prototypes; Recovery; Space Station Freedom; System Failures

19920047009

Fault diagnostics using expert systems

Golden, Constance J., Loral Space and Range Systems, USA; Jan 1, 1992; 7p; In English
Report No.(s): AIAA PAPER 92-0871; Copyright; Avail: Issuing Activity

The application of AI technologies to fault-diagnostic systems is reviewed to synthesize major findings and promising directions in the field. Included in the overview are rule-based expert systems, extended expert systems, and model-based reasoning systems. Rule-based expert systems include the fault-tree interpreter for test equipment controllers, an automobile-assembly diagnostic system, and a thallium diagnostic workstation. More complex fault-diagnosis treatments require the extended rule-based expert systems or model-based reasoning systems such as NASA's Knowledge-based Autonomous Test Engineer. The model-based Star-Plan system is an anomaly-resolution system for satellites which can diagnose problems and generate repair plans when no documented procedures exist. The need for reconfiguration and recovery expert systems is identified as is the need for the development of expert systems with broader domains of knowledge.

AIAA

Automatic Test Equipment; Expert Systems; Failure Analysis; Failure Modes; Knowledge Bases (Artificial Intelligence); Maintenance

19930049137 NASA Lyndon B. Johnson Space Center, Houston, TX, USA

Real-time automated failure analysis for on-orbit operations

Kirby, Sarah, NASA Lyndon B. Johnson Space Center, USA; Lauritsen, Janet, NASA Lyndon B. Johnson Space Center, USA; Pack, Ginger, NASA Johnson Space Center, USA; Ha, Anhhoang, NASA Lyndon B. Johnson Space Center, USA; Jowers, Steven, NASA Lyndon B. Johnson Space Center, USA; McNenny, Robert, NASA Lyndon B. Johnson Space Center, USA; Truong, The, McDonnell Douglas Space Systems Co., USA; Dell, James, Loral Space Information Systems, USA; In: Applications of artificial intelligence 1993: Knowledge-based systems in aerospace and industry; Proceedings of the Meeting, Orlando, FL, Apr. 13-15, 1993 (A93-33126 12-63); 1993, pp. 113-123.; In English; See also A93-33126; Copyright; Avail: Issuing Activity

A system which is to provide real-time failure analysis support to controllers at the NASA Johnson Space Center Control Center Complex (CCC) for both Space Station and Space Shuttle on-orbit operations is described. The system employs monitored systems' models of failure behavior and model evaluation algorithms which are domain-independent. These failure models are viewed as a stepping stone to more robust algorithms operating over models of intended function. The described system is designed to meet two sets of requirements. It must provide a useful failure analysis capability enhancement to the mission controller. It must satisfy CCC operational environment constraints such as cost, computer resource requirements, verification, and validation. The underlying technology and how it may be used to support operations is also discussed.

AIAA

Expert Systems; Failure Analysis; Failure Modes; Ground Based Control; Real Time Operation

19980155982

Validating the safety of embedded real-time control systems using FMEA

Goddard, Peter L., Hughes Aircraft Co., USA; 1993, pp. 227-230; In English; Copyright; Avail: Aeroplus Dispatch

Failure modes and effects analysis (FMEA) is examined as a cost effective way of assessing the impact of both hardware and software failures in embedded control systems. When hardware FMEAs are combined with software FMEAs, a complete assessment of system response to single point failures results. This assessment can be used to help produce robust hardware and software designs capable of providing safety critical services in an environment where hardware data integrity is not assured. When hardware and software FMEAs are supplemented with analysis techniques which assess operation under normal conditions and simulation of dynamic timing and failure occurrence conditions, a complete verification and validation of the safety characteristics of embedded real-time control system can be achieved.

AIAA

Software Reliability; Control Systems Design; Embedded Computer Systems

19980160685

Automating failure modes and effects analysis

Palumbo, Daniel L., NASA Langley Research Center, USA; 1994, pp. 304-309; In English; Copyright; Avail: Aeroplus Dispatch

This paper presents the current results of a multiyear effort to automate failure modes and effects analysis (FMEA) and its associated reliability analysis. A modular approach to modeling the system failure behavior is described. A component module definition contains a declarative part (inputs, outputs, and mode variables) and a behavioral part (mode logic). A system is defined as a block diagram of the component modules and their interconnects. The FMEA is produced through a simulation of the failure

propagation process. An actuator control system is analyzed and examples of automatically generated FMEA output are given. For each failure mode, the automated FMEA report lists all resulting component mode changes, declares a single point failure if appropriate, traces multiple failure effects, declares degraded modes of operation, and provides the probability of the failure mode occurring. It is believed that robust automated FMEA has been demonstrated. The modular approach unifies FMEA and associated analyses with other system behavior methodologies (such as performance analysis).

Author (AIAA)

Engine Airframe Integration; Failure Analysis; Engine Control; Reliability Analysis; Actuators

19990003240

Active diagnosis of discrete event systems

Sampath, Meera, Xerox Corp., USA; Lafortune, Stephane, Michigan, Univ., Ann Arbor; Teneketzis, Demosthenis, Michigan, Univ., Ann Arbor; 1997, pp. 2976-2983; In English

Contract(s)/Grant(s): DAAH04-96-1-0377; Copyright; Avail: AeroPlus Dispatch

While the need for accurate and timely diagnosis of system failures and the advantages of automated diagnostic systems are well appreciated, diagnosability considerations are often not explicitly taken into account in system design. In particular, design of the controller and that of the diagnostic subsystem are decoupled and this may significantly affect the diagnosability properties of a system. In this paper we present an integrated approach to control and diagnosis. More specifically, we present an approach for the design of diagnosable systems by appropriate design of the system controller. This problem, which we refer to as the active diagnosis problem, is studied in the framework of discrete event systems (DES). We formulate the active diagnosis problem as a supervisory control problem where the legal language is an 'appropriate' sublanguage of the system language. We present an iterative procedure for determining the supremal controllable, observable, and diagnosable sublanguage of the legal language, and for obtaining the supervisor that synthesizes this language. This procedure provides both a controller that ensures diagnosability of the closed-loop system and a diagnoser for on-line failure, diagnosis. We illustrate our approach using a simple pump-valve system.

Author (AIAA)

System Failures; Failure Analysis; Control Systems Design; Failure Modes

64

NUMERICAL ANALYSIS

Includes iteration, differential and difference equations, and numerical approximation.

19930007161 Groningen Rijksuniv., Dept. of Computing Science., Netherlands

A failures model for delay-insensitive processes and the soundness of laws for guarded choice

Lucassen, Paul G., Groningen Rijksuniv., Netherlands; Udding, Jan Tijmen, Groningen Rijksuniv., Netherlands; Jan 1, 1991; 31p; In English

Report No.(s): CS-9106; Avail: CASI; A03, Hardcopy; A01, Microfiche

A delay insensitive process models the asynchronous interaction by input and output between a system and its environment when no assumptions about delays of signals are made. A model underpinning an algebra for delay insensitive processes is presented. Laws in the algebra are given and proved correct with respect to the model. A delay insensitive process is receptive in the sense that inputs are never blocked. If a system is not ready to receive a particular input, its subsequent behavior is chaotic. The algebraic laws used in the design circuits are proved to be complete. The algebraic operators and their meanings in the model are presented. It is shown that the application of an operator to a di-process yields a di-process again and that the operators are continuous. The resulting model is simpler than the failures divergences model, because refusal sets can be eliminated.

ESA

Communication Theory; Delay; Failure Analysis; Failure Modes; Mathematical Models; Multichannel Communication; Operators (Mathematics); Sequential Control

STATISTICS AND PROBABILITY

Includes data sampling and smoothing; Monte Carlo method; time series and analysis; and stochastic processes.

19950012238 Sandia National Labs., Albuquerque, NM, USA

Can information surety be assessed with high confidence?

Lim, J. J., Sandia National Labs., USA; Fletcher, S. K., Sandia National Labs., USA; Halbgewachs, R. D., Sandia National Labs., USA; Jansma, R. M., Sandia National Labs., USA; Sands, P. D., Sandia National Labs., USA; Watterberg, P. A., Sandia National Labs., USA; Wyss, G. D., Sandia National Labs., USA; Jan 1, 1994; 13p; In English; High Consequence Operations Safety Symposium, 12-14 Jul. 1994, Albuquerque, NM, USA

Contract(s)/Grant(s): DE-AC04-94AL-85000

Report No.(s): DE94-015805; SAND-94-1796C; CONF-940788-3; Avail: CASI; A03, Hardcopy; A01, Microfiche

Several basic reasons are given to support the position that an integrated, systems methodology entailing probabilistic assessment offers the best means for addressing the problems in software safety. The recognized hard problems in software safety, or safety per se, and some of the techniques for hazard identification and analysis are then discussed relative to their specific strengths and limitations. The paper notes that it is the combination of techniques that will lead to safer systems, and that more experience, examples, and applications of techniques are needed to understand the limits to which software safety can be assessed. Lastly, some on-going project work at Sandia National Laboratories on developing a solution methodology is presented.

DOE

Computer Programs; Failure Analysis; Failure Modes; Fault Trees; Software Reliability

SYSTEMS ANALYSIS AND OPERATIONS RESEARCH

Includes mathematical modeling of systems; network analysis; mathematical programming; decision theory; and game theory.

19800015622 Johns Hopkins Univ., Dept. of Electrical Engineering., Baltimore, MD, USA

Intermittent/transient faults in computer systems: Executive summary

Masson, G. M., Johns Hopkins Univ., USA; Apr 1, 1980; 39p; In English

Contract(s)/Grant(s): NSG-1442

Report No.(s): NASA-CR-159229; Avail: CASI; A03, Hardcopy; A01, Microfiche

An overview of an approach for diagnosing intermittent/transient (I/T) faults is presented. The development of an interrelated theory and experimental methodology to be used in a laboratory situation to measure the capability of a fault tolerant computing system to diagnose I/T faults, is discussed. to the extent that such diagnosing capability is important to reliability in fault tolerant computing systems, this theory and supporting methodology serves as a foundation for validation efforts.

E.D.K.

Computer Programs; Computer Systems Design; Error Correcting Codes; Error Detection Codes; Failure Analysis; Failure Modes

19850067376

Automated FMEA - Status and future

Dussault, H. B., USAF, Rome Air Development Center, USA; Jan 1, 1984; 5p; In English; Annual Reliability and Maintainability Symposium, January 24-26, 1984, San Francisco, CA; Sponsored by IEEE, AIAA, ASME; See also A85-49526 24-38

Contract(s)/Grant(s): F30602-82-C-0072; Avail: Issuing Activity

If Failure Modes and Effects Analyses (FMEAs) are to provide meaningful and useful results, techniques which are both standard and automated must be developed. A survey of current FMEA techniques and automation tools is presented. The feasibility and practicality of developing a standardized, automated FMEA technique is addressed. The framework for a computerized technique, based upon matrix FMEA and consistent with the guidance provided in MIL-STD-1629A, is discussed. The technique provides: a functional top-down FMEA during early development phases; a top-down and bottom-up approach

when equipment/system hardware elements and their configuration have been defined; and information which can be used for maintainability, testability, and logistics studies. The paper addresses the specifics of this procedure and its application.

AIAA

Automatic Test Equipment; Computer Aided Design; Failure Analysis; Failure Modes; Reliability Analysis; Technology Assessment

19880061266 NASA Marshall Space Flight Center, Huntsville, AL, USA

Failure mode and effects analysis (FMEA) for the Space Shuttle solid rocket motor

Russell, D. L., NASA Marshall Space Flight Center, USA; Blacklock, K., NASA Marshall Space Flight Center, USA; Langhenry, M. T., Martin Marietta Corp., USA; Jul 1, 1988; 14p; In English

Report No.(s): AIAA PAPER 88-3420; Copyright; Avail: Issuing Activity

The recertification of the Space Shuttle Solid Rocket Booster (SRB) and Solid Rocket Motor (SRM) has included an extensive rewriting of the Failure Mode and Effects Analysis (FMEA) and Critical Items List (CIL). The evolution of the groundrules and methodology used in the analysis is discussed and compared to standard FMEA techniques. Especially highlighted are aspects of the FMEA/CIL which are unique to the analysis of an SRM. The criticality category definitions are presented and the rationale for assigning criticality is presented. The various data required by the CIL and contribution of this data to the retention rationale is also presented. As an example, the FMEA and CIL for the SRM nozzle assembly is discussed in detail. This highlights some of the difficulties associated with the analysis of a system with the unique mission requirements of the Space Shuttle.

AIAA

Failure Modes; Reliability Analysis; Space Shuttle Boosters; Spacecraft Reliability

19900016322 Boeing Advanced Systems Co., Seattle, WA, USA

Reliability model generator specification *Final Report*

Cohen, Gerald C., Boeing Advanced Systems Co., USA; Mccann, Catherine, Boeing Advanced Systems Co., USA; Mar 1, 1990; 247p; In English

Contract(s)/Grant(s): NAS1-18099; RTOP 505-66-71-02

Report No.(s): NASA-CR-182005; NAS 1.26:182005; Avail: CASI; A11, Hardcopy; A03, Microfiche

The Reliability Model Generator (RMG), a program which produces reliability models from block diagrams for ASSIST, the interface for the reliability evaluation tool SURE is described. An account is given of motivation for RMG and the implemented algorithms are discussed. The appendices contain the algorithms and two detailed traces of examples.

CASI

Computer Programs; Failure Analysis; Failure Modes; Flight Control; Reliability Analysis; Specifications

19920024239 NASA Langley Research Center, Hampton, VA, USA

Advanced techniques in reliability model representation and solution

Palumbo, Daniel L., NASA Langley Research Center, USA; Nicol, David M., College of William and Mary, USA; Oct 1, 1992; 18p; In English

Contract(s)/Grant(s): RTOP 505-64-10-07

Report No.(s): NASA-TP-3242; L-17048; NAS 1.60:3242; Avail: CASI; A03, Hardcopy; A01, Microfiche

The current tendency of flight control system designs is towards increased integration of applications and increased distribution of computational elements. The reliability analysis of such systems is difficult because subsystem interactions are increasingly interdependent. Researchers at NASA Langley Research Center have been working for several years to extend the capability of Markov modeling techniques to address these problems. This effort has been focused in the areas of increased model abstraction and increased computational capability. The reliability model generator (RMG) is a software tool that uses as input a graphical object-oriented block diagram of the system. RMG uses a failure-effects algorithm to produce the reliability model from the graphical description. The ASSURE software tool is a parallel processing program that uses the semi-Markov unreliability range evaluator (SURE) solution technique and the abstract semi-Markov specification interface to the SURE tool (ASSIST) modeling language. A failure modes-effects simulation is used by ASSURE. These tools were used to analyze a significant portion of a complex flight control system. The successful combination of the power of graphical representation,

automated model generation, and parallel computation leads to the conclusion that distributed fault-tolerant system architectures can now be analyzed.

CASI

Applications Programs (Computers); Computer Systems Performance; Computerized Simulation; Distributed Processing; Failure Analysis; Failure Modes; Fault Tolerance; Flight Control; Mathematical Models; Parallel Processing (Computers); Reliability Analysis

19980155978

Combining sneak circuit analysis and failure modes and effects analysis

Savakoor, Devyani S., South Carolina, Univ., Columbia, USA; Bowles, John B., South Carolina, Univ., Columbia; Bonnell, Ronald D., South Carolina, Univ., Columbia; 1993, pp. 199-205; In English; Copyright; Avail: Aeroplus Dispatch

The feasibility of integrating Failure Modes and Effects Analysis (FMEA) and Sneak Circuit Analysis (SCA) into a comprehensive reliability analysis technique is examined especially from the perspective of automation. FMEA looks at a system's strengths and weaknesses; SCA looks for latent circuit conditions which may lead to unplanned or unexpected modes of operation. The goals of the two techniques complement each other and combining them results in a more comprehensive analysis than either technique alone. The rich collection of heuristics used in SCA can be applied for design validation and can also be used as design guidelines at various stages of system design. At both the functional level and at the component level, the combined analysis is done using the same circuit representation as for the SCA and for the FMEA, and it draws on the same database. The integrated approach results in a more thorough examination of the system than separate SCA and FMEA analyses would have.

Author (AIAA)

Circuit Reliability; Failure Modes; Reliability Engineering; Sneak Circuit Analysis

19980155995

Functional reasoning in a failure modes and effects analysis (FMEA) expert system

Russomanno, David J., Integraph Corp., USA; Bonnell, Ronald D., South Carolina, Univ., Columbia; Bowles, John B., South Carolina, Univ., Columbia; 1993, pp. 339-347; In English; Copyright; Avail: Aeroplus Dispatch

An Expert System for Failure Mode and Effects Analysis (XFMEA) must provide a full spectrum of assistance that the reliability and design engineer can exploit. The goal is not only to automate the collection and storage of data and facilitate the generation of reports, but also to provide assistance in the reasoning process. This paper addresses functional FMEA methodology in the design of an expert system; specifically, the issue of representing the knowledge of how systems work is approached from a functional perspective. A knowledge base, organized around a functional representation, provides the inference procedure with a focus of attention directed toward expected goals and guides the reasoning process in determining the effects of a system's failure modes. The functional representation described includes relationships to more detailed schemes, including numerical techniques and qualitative simulations of the causal behavior of systems. A functional representation is domain-general, in that functional primitives provide a language that is more general than any one system being modeled. The blackboard framework is proposed as a comprehensive problem-solving architecture for integrating the functional approach with other simulation and representation techniques.

Author (AIAA)

Failure Modes; Expert Systems; Functional Analysis; Failure Analysis

19980175169

Failure mode, effects, and criticality analysis

Bowles, John B., South Carolina, Univ., Columbia, USA; Bonnell, Ronald D., South Carolina, Univ., Columbia; 1995; In English; Copyright; Avail: Aeroplus Dispatch

Failure mode, effects, and criticality analysis (FMECA) is potentially one of the most beneficial and productive tasks in a well structured reliability program. It is a structured qualitative analysis of a system to identify potential system failure modes, their causes, and the effects associated with each failure mode. Unfortunately, a FMECA is most often done as a task nears the end of the design process, when its influence on the system design is minimal. This tutorial focuses on how to perform a FMECA and how it should be integrated into the design process. The emphasis is on the FMECA's role in design and the methodology for doing the analysis. Several examples and an extensive bibliography are included.

Author (AIAA)

Failure Modes; Failure Analysis; Reliability Engineering

71 ACOUSTICS

Includes sound generation, transmission, and attenuation. For noise pollution see 45 Environment Pollution. For aircraft noise see also 02 Aerodynamics and 07 Aircraft Propulsion Propulsion and Power.

1986001446 NASA Langley Research Center, Hampton, VA, USA

Investigation of composite materials property requirements for sonic fatigue research

Patrick, H. V. L., Embry-Riddle Aeronautical Univ., USA; Aug 1, 1985; 37p; In English

Contract(s)/Grant(s): RTOP 505-33-53-03

Report No.(s): NASA-TM-87601; NAS 1.15:87601; Avail: CASI; A03, Hardcopy; A01, Microfiche

Experimental techniques for determining the extensional and bending stiffness characteristics for symmetric laminates are presented. Vibrational test techniques for determining the dynamic modulus and material damping are also discussed. Partial extensional stiffness results initially indicate that the laminate theory used for predicting stiffness is accurate. It is clearly shown that the laminate theory can only be as accurate as the physical characteristics describing the lamina, which may vary significantly. It is recommended that all of the stiffness characteristics in both extension and bending be experimentally determined to fully verify the laminate theory. Dynamic modulus should be experimentally evaluated to determine if static data adequately predicts dynamic behavior. Material damping should also be ascertained because laminate damping is an order of magnitude greater than found in common metals and can significantly effect the displacement response of composite panels.

CASI

Composite Materials; Epoxy Compounds; Failure Analysis; Failure Modes; Graphite

19960046422

Identification of failure modes of carbon-carbon composites at various processing stages using the acoustic emission technique

Vaidya, U. K., Tuskegee Univ, USA; Raju, P. K.; Journal of Vibration and Acoustics, Transactions of the ASME; July 1996; ISSN 1048-9002; 118, 3, pp. 446-453; In English; Copyright; Avail: Issuing Activity

In the fabrication of carbon-carbon (C/C) composites, the first carbonization process is crucial, as the mechanical properties of the composite are completely altered at this stage. Some predominant effects of this process, in the composite, are development of delaminations, fiber breaks, distributed porosity and formation of transverse cracks in the matrix. These effects are to some extent, beneficial, during latter processing of the composite. However, excessive occurrence of any of these effects is undesirable. Keeping this in view, the present study focuses on the utilization of acoustic emission (AE) (as a nondestructive evaluation (NDE)) technique for identification and characterization of failure modes of C/C composites at several processing stages of C/C composites. Primarily, acoustic emission (AE) has been used to study the failure modes of C/C composites at the as-cured, carbonized and densified stages using AE parameters such as the peak amplitude, event duration and energy content of the AE signals. These parameters have been related to the initiation and progression of matrix cracking, fiber breakage and delaminations which occur in the composite at the as-cured, carbonized and densified stages.

Author (EI)

Acoustic Emission; Carbon-Carbon Composites; Crack Initiation; Delaminating; Densification; Failure Analysis; Failure Modes; Microstructure; Nondestructive Tests

72 ATOMIC AND MOLECULAR PHYSICS

Includes atomic and molecular structure, electron properties, and atomic and molecular spectra. For elementary particle physics see 73 Nuclear Physics.

19960030764

Single particle-induced latchup

Bruguier, G., Universite Montpellier II, France; Palau, J.-M.; IEEE Transactions on Nuclear Science; April 1996; ISSN 0018-9499; 43, 2, pt. 1, pp. 522-532; In English; Copyright; Avail: Issuing Activity

This paper presents an up-to-date overview of the single-event latchup (SEL) hard failure mode encountered in electronic device applications involving heavy ion environment. This phenomenon is specific to CMOS technology. Single-event latchup is discussed after a short description of the effects induced by the interaction of a heavy ion with silicon. Understanding these effects is necessary to understand the different failures. This paper includes a description of the latchup phenomenon and the

different triggering modes, reviews of models and hardening solutions, and finally presents new developments in simulation approaches.

Author (EI)

CMOS; Electrical Properties; Failure Analysis; Failure Modes; Heavy Ions; Integrated Circuits; Ions; Radiation Effects

73

NUCLEAR PHYSICS

Includes nuclear particles; and reactor theory. For space radiation see 93 Space Radiation. For atomic and molecular physics see 72 Atomic and Molecular Physics. For elementary particle physics see 77 Physics of Elementary Particles and Fields. For nuclear astrophysics see 90 Astrophysics.

19950018028 Tampere Univ. of Technology, Finland

Availability analysis of a 100 kWh superconducting magnetic energy storage

Maekinen, H., Tampere Univ. of Technology, Finland; Mikkonen, R., Tampere Univ. of Technology, Finland; Jan 1, 1994; 87p; In English

Report No.(s): DE95-737621; TTKK/TST-2/94; Avail: CASI; A05, Hardcopy; A01, Microfiche

Superconducting Magnetic Energy Storage (SMES) is one of the possible and useful applications of modern superconducting technology. It is known that some loads on electricity distribution networks are particularly sensitive to short power interruptions and voltage sags. Different ranges of SMES applications have been widely discussed for large scale units (1 MWh - 1 GWh) as well as for small and medium scale units (1 kWh - 1 MWh). The major components of a SMES system are the superconducting magnet winding, the cryogenic refrigeration system and the power conditioning system, which interfaces the coil to the utility grid and applied load. The SMES winding is cooled by a cryogenic coolant: liquid helium for LTS (low temperature superconductor) wires; gaseous helium, liquid hydrogen or liquid nitrogen for HTS (high temperature superconductor) wires. In addition the higher operating temperature of HTS materials also means higher refrigeration efficiencies, greater reliability and easier acceptance within the utility community. It has been estimated that applying HTS materials in a SMES system will reduce the capital costs some 14-26 %. In this calculation it has been assumed that the price of HTS material is equivalent to that of LTS material. This report deals with the availability aspects of a 100 kWh SMES. A conceptual design of a reference unit has been used as a basis of the study. Therefore the lack of the detailed design leads to uncertainty in evaluating the failure data for single components. The failure rate data are mainly adopted from fusion data sources. This extrapolation is problematic, but in most cases the only way to get results at all. The method used is based on the failure modes, effects and criticality analysis, FMECA. Fault trees describe the outage logic based on the functional analysis. Event trees clarify the consequences of the primary events and the criticality of these consequences are expressed as system down times.

DOE

Availability; Design Analysis; Failure Analysis; Failure Modes; Magnetic Energy Storage; Reliability Analysis; Superconducting Magnets

75

PLASMA PHYSICS

Includes magnetohydrodynamics and plasma fusion. For ionospheric plasmas see 46 Geophysics. For space plasmas see 90 Astrophysics.

19880009034 Japan Atomic Energy Research Inst., Tokyo, Japan

Conceptual design study of Fusion Experimental Reactor (FY86 FER): Safety

Seki, Yasushi, Japan Atomic Energy Research Inst., Japan; Iida, Hiromasa, Japan Atomic Energy Research Inst., Japan; Honda, Tsutomu, Japan Atomic Energy Research Inst., Japan; Aug 1, 1987; 240p; In Japanese

Report No.(s): DE88-751071; JAERI-M-87-111; Avail: CASI; A11, Hardcopy; A03, Microfiche

This report describes the study on safety for FER (Fusion Experimental Reactor) which has been designed as a next step machine to the JT-60. Though the final purpose of this study is to have an image of design base accident, maximum credible accident and to assess their risk or probability, etc., as FER plant system, the emphasis of this years study is placed on fuel-gas circulation system where the tritium inventory is maximum. The report consists of two chapters. The first chapter summarizes the FER system and describes FMEA (Failure Mode and Effect Analysis) and related accident progression sequence for FER plant system as a whole. The second chapter of this report is focused on fuel-gas circulation system including purification, isotope

separation and storage. Probability of risk is assessed by the probabilistic risk analysis (PRA) procedure based on FMEA, ETA and FTA.

DOE

Fusion Reactors; Reactor Design; Safety Management; Specifications

81

ADMINISTRATION AND MANAGEMENT

Includes management planning and research.

19880010818 National, Committee on Shuttle Criticality Review and Hazard Analysis Audit., Academy of Engineering, Washington, DC, USA

Post-Challenger evaluation of space shuttle risk assessment and management

Jan 1, 1988; 150p; In English

Contract(s)/Grant(s): NASW-4003

Report No.(s): NASA-CR-182461; NAS 1.26:182461; PB88-190624; Avail: CASI; A07, Hardcopy; A02, Microfiche

As the shock of the Space Shuttle Challenger accident began to subside, NASA initiated a wide range of actions designed to ensure greater safety in various aspects of the Shuttle system and an improved focus on safety throughout the National Space Transportation System (NSTS) Program. Certain specific features of the NASA safety process are examined: the Critical Items List (CIL) and the NASA review of the Shuttle primary and backup units whose failure might result in the loss of life, the Shuttle vehicle, or the mission; the failure modes and effects analyses (FMEA); and the hazard analysis and their review. The conception of modern risk management, including the essential element of objective risk assessment is described and it is contrasted with NASA's safety process in general terms. The discussion, findings, and recommendations regarding particular aspects of the NASA STS safety assurance process are reported. The 11 subsections each deal with a different aspect of the process. The main lessons learned by SCRHAAC in the course of the audit are summarized.

B.G.

Accidents; Hazards; Project Management; Risk; Safety Factors; Space Transportation System

19900064087

Rational decision making - Structuring of design meetings

Vliegen, Hugo J. W., Philips Corp., Netherlands; Van Mal, Herman H., Eindhoven, Technische Universiteit, Netherlands; IEEE Transactions on Engineering Management; Aug 1, 1990; ISSN 0018-9391; 37, pp. 185-190; In English; Copyright; Avail: Issuing Activity

The design process is discussed from the viewpoint of decision-making. In sorting design problems the following stages of strategy, tactics, and execution (called the decision-making cycle), are assumed to always occur. Particular design meetings to obtain improved structuring of the design process are included in this decision-making cycle. The design meetings include decision analysis (DA), potential problem analysis (PPA), failure-mode and effect analysis (FMEA), and design for production (DFP). Progress controls in the decision-making cycle are included to ensure faster feedback about the progress of a project involving checks of the management aspects quality, throughput time, and costs. The necessity of this approach is illustrated by means of data gathered from an industrial automation department.

AIAA

Decision Making; Industrial Management; Systems Engineering

20000005998

Project management FMEA

Aimono, Kunio, High-Reliability Components Corp., Tokyo, Japan; Horiguchi, Hiroshi, High-Reliability Components Corp., Tokyo, Japan; Fukushima, Toshio, High-Reliability Components Corp., Tokyo, Japan; Oct. 1999; In English

Report No.(s): IAA Paper 99-6207; Copyright; Avail: Aeroplus Dispatch

The success of a project is attained by the success of many key elements ranging from technology and performance to cost and schedule. Project management trades off these elements for maximum success. Among many project management activities, the risk management constitutes a major and critical part. The risk management distinguishes the potential risk of the project,

analyzes it, and establishes counteractions for effective prevention of problems. As one technique of this risk management, we propose Project Management FMEA.

Author (AIAA)

Project Management; Cost Analysis; Scheduling; Space Programs; Failure Analysis

82

DOCUMENTATION AND INFORMATION SCIENCE

Includes information management; information storage and retrieval technology; technical writing; graphic arts; and micrography. For computer documentation see 61 Computer Programming and Software.

19960014762 South Carolina Univ., Columbia, SC USA

A fuzzy cognitive map knowledge representation for performing Failure Modes and Effects Analysis

Pelaez, Colon Enrique, South Carolina Univ., USA; Jan. 01, 1994; 175p; In English; No Copyright; Avail: Univ. Microfilms Order No. DA9517301, Hardcopy, Microfiche

Automating Failure Modes and Effects Analysis (FMEA) to do more than simple clerical functions, data collection, data-base manipulation, and automatic report generation, has been a long sought goal of reliability analysts. This dissertation investigates the application of fuzzy knowledge representations and inferencing techniques using fuzzy cognitive maps, and fuzzy knowledge combination to a system for failure modes and effects analysis. Its main contribution is the specification of a graphical-causal representation of failures, their manipulation using fuzzy logic, and a strategy for combining these graphical representations to resolve conflicting expert opinions during a system's design evaluation. The strategy proposed focuses on the knowledge-use level perspective to provide a complete understanding of the problem. Fuzzy set theory and fuzzy cognitive maps are utilized to represent causality when performing the FMEA. Failure modes, effects, causes, etc., are represented through a set of concept nodes, and weighted linguistic relationships between concepts to express causality. This research seeks to establish the theoretical background that is required for acquiring- and representing causality graphically and linguistically, its manipulation using fuzzy logic techniques, and later the combination of the expert's graphical representation to handle consensus FMEA. Graphic-causal FMEA is emphasized with motivation to include linguistic descriptions of causal relationships and possible semantic constraints. Furthermore, this research argues that the fuzzy cognitive map model provides a more suitable and more natural representation of the kind of knowledge used in FMEA. Some experiments are conducted to illustrate the utility of the developed strategy. Although some extensions to the proposed method are necessary to build a meaningful prototype system; the knowledge representation, inferencing strategy and knowledge combination approaches developed in this research provide a solid ground for building an intelligent knowledge-based FMEA system.

Dissert. Abstr.

Fuzzy Systems; Knowledge Representation; Failure Analysis; Reliability Engineering; Expert Systems

85

TECHNOLOGY UTILIZATION AND SURFACE TRANSPORTATION

Includes aerospace technology transfer; urban technology; surface and mass transportation. For related information see 03 Air Transportation and Safety, 16 Space Transportation and Safety, and 44 Energy Production and Conversion. For specific technology transfer applications see also the category where the subject is treated.

19810016459 NASA Lewis Research Center, Cleveland, OH, USA

System safety in Stirling engine development

Bankaitis, H., NASA Lewis Research Center, USA; Jan 1, 1981; 29p; In English; 5th; Intern. Systems Safety Conf., 26-31 Jul. 1981, Denver, CO, USA

Contract(s)/Grant(s): DE-AI01-77CS-51040; RTOP 778-35-03

Report No.(s): NASA-TM-82615; DOE/NASA/51040-25; E-867; Avail: CASI; A03, Hardcopy; A01, Microfiche

The DOE/NASA Stirling Engine Project Office has required that contractors make safety considerations an integral part of all phases of the Stirling engine development program. As an integral part of each engine design subtask, analyses are evolved to determine possible modes of failure. The accepted system safety analysis techniques (Fault Tree, FMEA, Hazards Analysis,

etc.) are applied in various degrees of extent at the system, subsystem and component levels. The primary objectives are to identify critical failure areas, to enable removal of susceptibility to such failures or their effects from the system and to minimize risk. T.M.

Automobile Engines; Design Analysis; Engine Design; Safety Management; Stirling Cycle; Stirling Engines

99 GENERAL

Includes aeronautical, astronautical, and space science related histories, biographies, and pertinent reports too broad for categorization; histories or broad overviews of NASA programs such as Apollo, Gemini, and Mercury spacecraft, Earth Resources Technology Satellite (ERTS), and Skylab; NASA appropriations hearings.

19710052620

Status of failure /hazard/ mode and effect analysis, fault tree analysis, and prediction, apportionment and assessment
Grose, V. L.; Jan 1, 1971; 9p; In English; 10TH; Reliability And Maintainability Conference, Jun. 27-30, 1971, Anaheim, CA; Conference Sponsored By The American Society Of Mechanical Engineers, The Society Of Automotive Engineers, And The American Inst. Of Aeronautics And Astronautics.; Copyright; Avail: Issuing Activity

Fault tree, failure mode and effect analysis, prediction apportionment and assessment, discussing system effectiveness
AIAA

Failure Analysis; Failure Modes; Performance Prediction; System Effectiveness; Trees (Mathematics)

19740078920 North American Rockwell Corp., Space Div., Downey, CA, USA

Solar-powered space station preliminary design. Volume 9: FMEA data analysis, hazards analysis

Jul 1, 1970; 284p; In English

Contract(s)/Grant(s): NAS9-9953

Report No.(s): NASA-CR-140212; MSC-00720; SD-70-159-9; Avail: CASI; A13, Hardcopy, Unavail. Microfiche
No abstract.

Failure Modes; Hazards; Solar Generators; Spacecraft Design

19750068875 Westinghouse Electric Corp., Astronuclear Lab., Pittsburgh, PA, USA

XE-1 Control Drum System failure mode analysis

Starek, R. M., Westinghouse Electric Corp., USA; Ottenheimer, F., Westinghouse Electric Corp., USA; Wandell, G. F., Westinghouse Electric Corp., USA; Dec 30, 1966; 84p; In English; Sponsored by ERDA

Report No.(s): WANL-TME-1523; Avail: CASI; A05, Hardcopy, Microfiche

No abstract.

Failure Analysis; Failure Modes; Nuclear Reactor Control; Reactor Safety

19760069385 Westinghouse Astronuclear Lab., Pittsburgh, PA, USA

Mode of failure analysis summary. NERVA B-2 reactor

Neal, R. A., Westinghouse Astronuclear Lab., USA; Mar 9, 1962; 35p; In English; Sponsored by NASA and ERDA

Report No.(s): NASA-CR-147258; WANL-TNR-042; Avail: CASI; A03, Hardcopy, Microfiche

No abstract.

Failure Analysis; Failure Modes; Nuclear Engine For Rocket Vehicles; Reactor Design

19760072283 Westinghouse Astronuclear Lab., Pittsburgh, PA, USA

Failure mode analysis summary: NERVA control drum actuator proposed by General Electric (model AG-14)

Spezialetti, I. R., Westinghouse Astronuclear Lab., USA; Jan 15, 1963; 41p; In English; Sponsored by NASA

Report No.(s): NASA-CR-148449; WANL-TNR-081; Avail: CASI; A03, Hardcopy, Microfiche

No abstract.

Actuators; Failure Analysis; Failure Modes; Nuclear Engine For Rocket Vehicles; Pneumatic Control

19990077710

Failure mode and effect analysis on ITER heat transfer systems

Pinna, T., ENEA, Italy; Caporali, R.; Cambi, G.; Burgazzi, L.; Poucet, A.; Porfiri, M. T.; Fusion Engineering and Design; Sep 03, 1998; ISSN 0920-3796; Volume 42, Pt C, pp. 431-436; In English; 1997 4th International Symposium on Fusion Nuclear Technology. Part C, Apr. 6-11, 1997, Tokyo, Japan; Copyright; Avail: Issuing Activity

The complexity of the ITER (International Thermonuclear Experimental Reactor) plant and the inventories of radioactive materials involved in its operation require a systematic approach to perform detailed safety analyses during the various stages of the project in order to demonstrate compliance with the safety requirements. The failure mode and effect analysis (FMEA) methodology has been chosen to perform the safety analysis at system level for ITER. The main purposes of the work are: to identify important accident initiators, to find out the possible consequences for the plant deriving from component failures, identify individual possible causes, identify mitigating features and systems, classify accident initiators in postulated initiating events (PIEs), define the deterministic analyses which allow the possible accident sequences to be quantified, both in terms of expected frequency and radiological consequences, and consequently, to ascertain the fulfillment of ITER safety requirements. This paper summarizes the FMEA performed for the heat transfer systems (HTSs).

Author (EI)

Failure Analysis; Failure Modes; Fusion Reactors; Thermonuclear Reactions; Heat Exchangers; Nuclear Research and Test Reactors; Accident Prevention

Subject Terms Index

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